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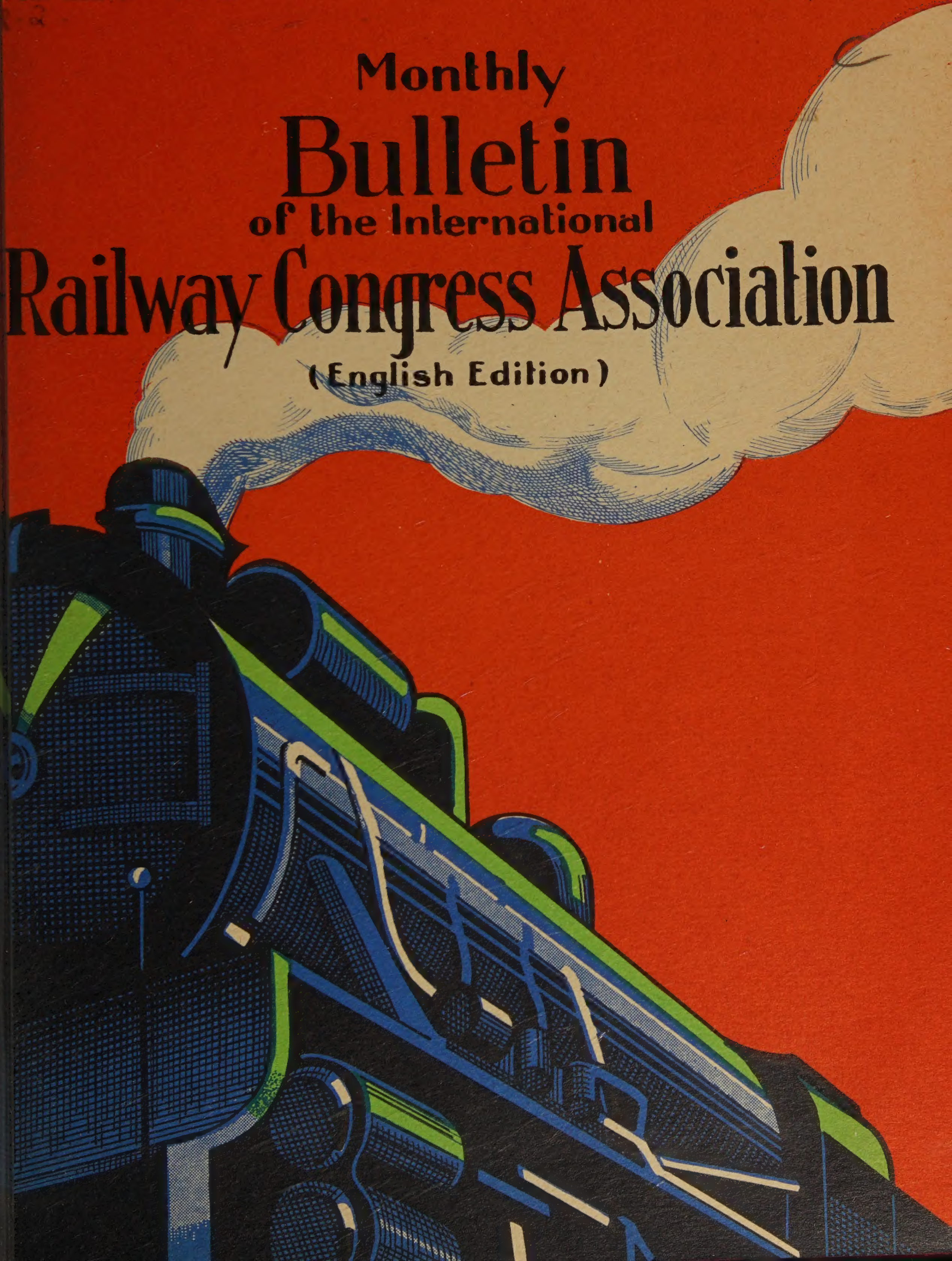

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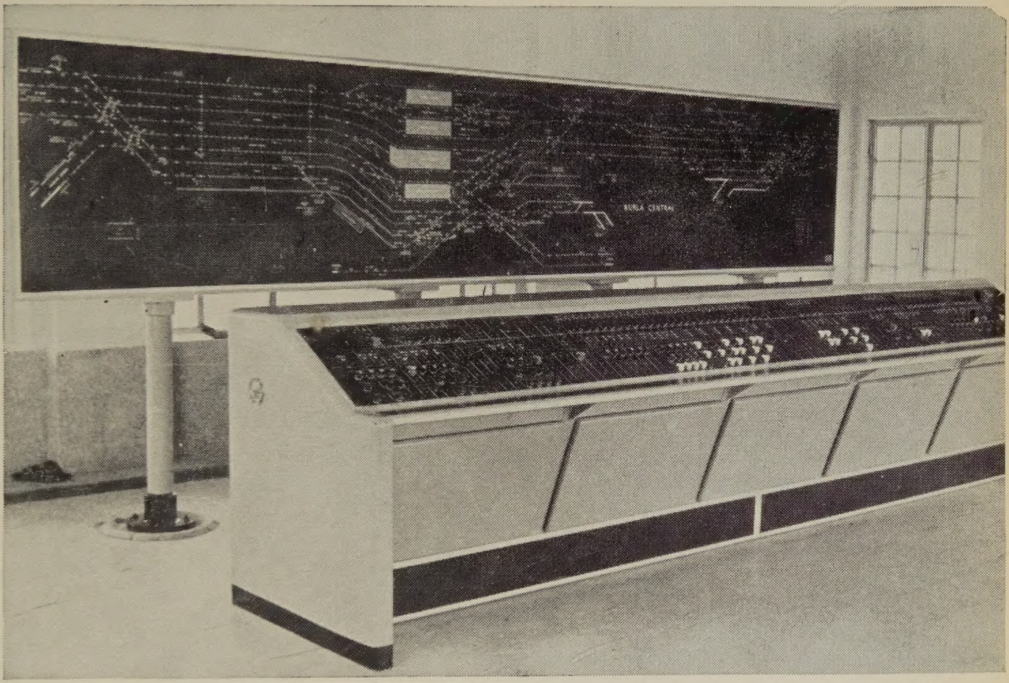

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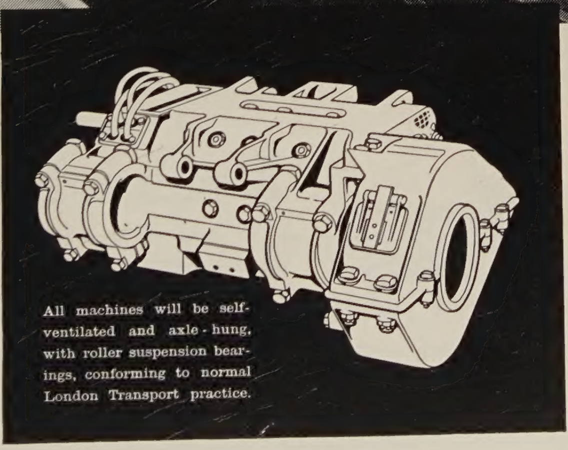

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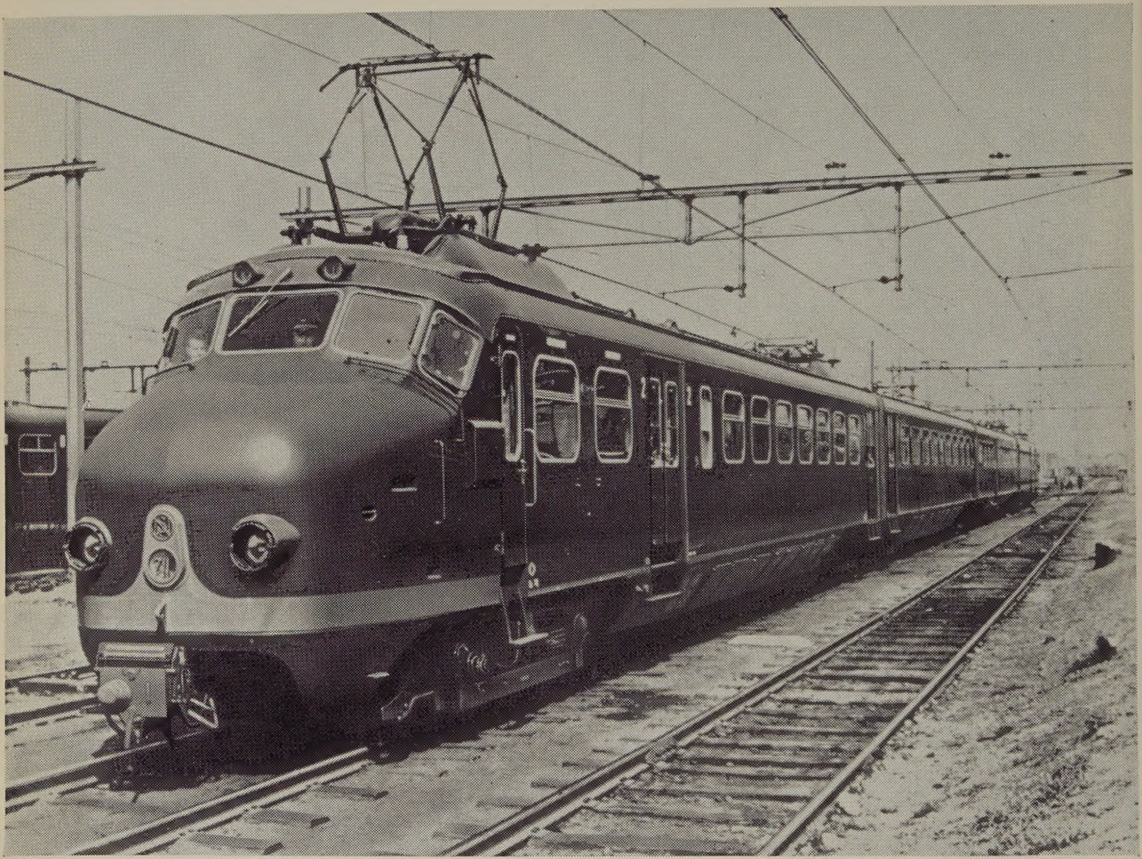

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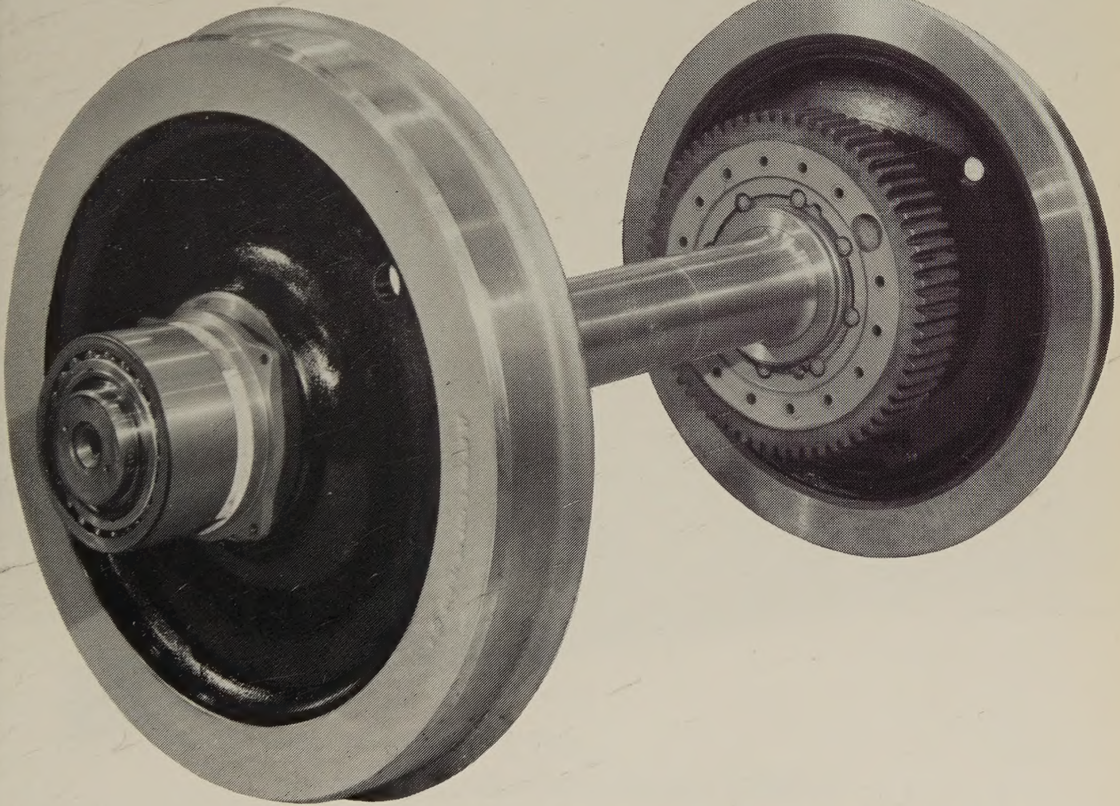

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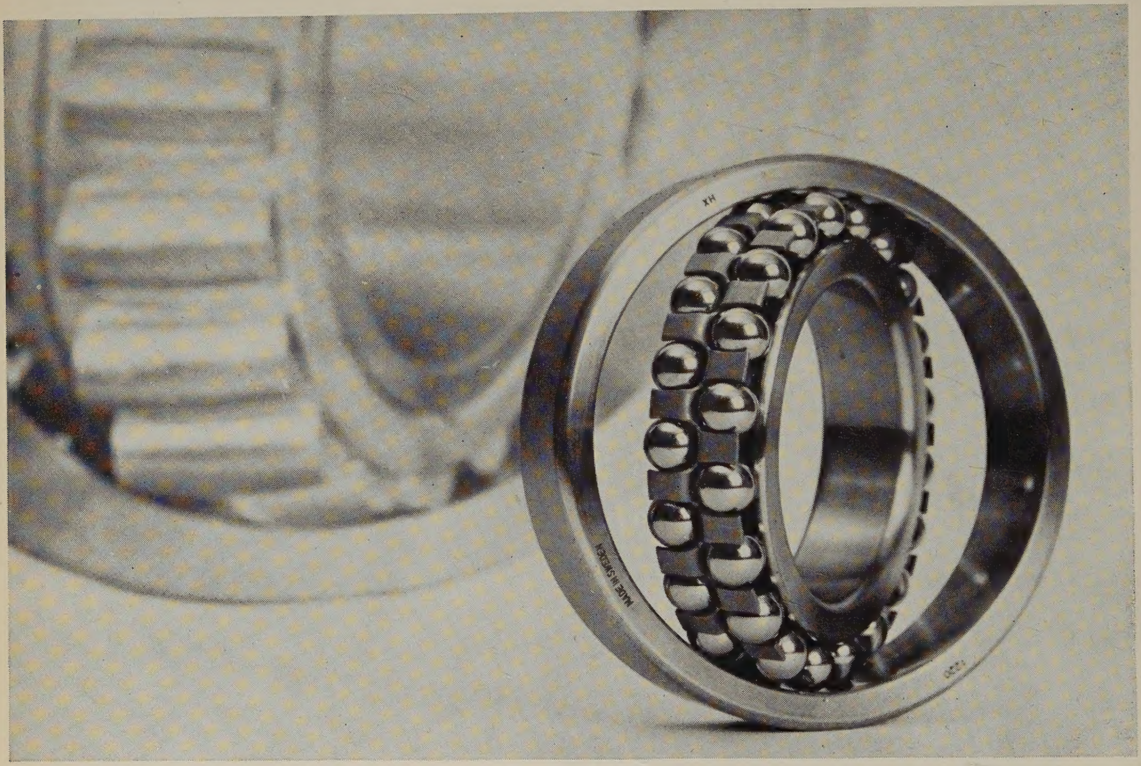

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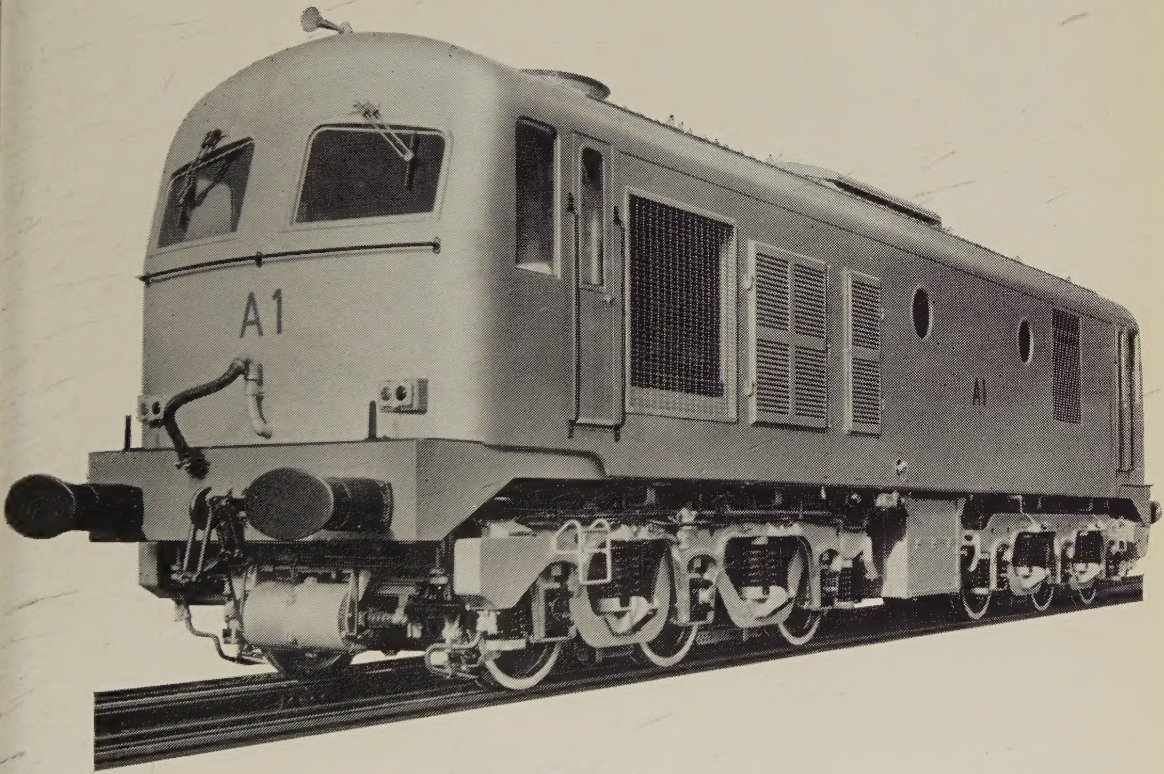

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An edition in French is also published.

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BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION)

[656 .254]

The research for the ideal device for stopping trains automatically,

by H. Verbeeck,

Ingénieur principal à la Société Nationale des Chemins de fer belges.

PART 1

EXAMINATION OF THE PROGRAMMES CARRIED OUT WITH DEVICES FOR STOPPING TRAINS AUTOMATICALLY, TESTED ON THE S.N.C.B.

1. Development of automatic stopping equipment on the Belgian National Railways (S.N.C.B.).

The traction units of the S.N.C.B. driven by one man are fitted with a dead man's handle device which, should it come into play, cuts out the tractive effort and brakes the train.

The driver has to press on a levèr or pedal to prevent this device from coming into action.

On the other hand, on the important lines of the system, the warning signals are reinforced with a track contact which checks the vigilance of the driver by making a recording on the speed recorder band with which all locomotives running at more than 80 km/h are equipped.

Before running past a warning signal at danger (or a speed reduction signal), the driver must prove his vigilance by pressing a button provided with this object in view; apart from this « mark of vigilance » a whistle blows when a warning signal at stop is passed; the driver stops the whistle by pressing another button.

The above mentioned safety devices have certain drawbacks :

— If anything is wrong with the batteries feeding the track contact, the warning device does not act; its working may be upset in winter by the formation of ice or a heavy fall of snow;

— The speed recorder merely records the vigilance of the driver and reminds him — by the whistle — that he has run past a signal at danger; the device does not automatically stop the train if the driver fails to do so.

Being constantly on the alert to increase safety of operating, the S.N.C.B. during the spring of 1949 carried out a series of trials with an automatic stopping device.

This equipment works by the induction of current in electro-magnets fitted on the track and on the rolling stock, the necessary current being supplied by the auxiliary equipment of the power unit.

Whenever a signal at danger is run past, this device causes an interruption in the traction current and applies the brakes, unless the driver is on the lookout and substitutes the normal braking by working the driver's brake valve, and prevents the emergency braking by pressing a special button.

The equipment has been designed in such a way that it always acts in the direction of safety, any irregularity always automatically stopping the train.

The results of the trials carried out with this device were satisfactory : the equipment never worked unexpectedly, but always braked the train whenever a warning signal fitted with an electro-magnet was passed without pressing the special button.

The generalization of an automatic train stopping device worked by inductive current would however have involved considerable expenditure both as regards equipping the rolling stock and the fixed installations. To a certain extent, it would double the track contacts which, provided they are regularly maintained, assure relatively sufficient security of working.

In addition, the installation of the equipment on all the rolling stock and on the track would have to be spread over a very long period during which the cost involved would only show a relatively low return.

It is important to note that if the functioning of these devices with a track contact is satisfactory, such a solution allows of any system being used on the rolling stock, which is not the case with devices working by induction.

All these considerations led the S.N.C.B. to design equipment for the rolling stock working from a track contact, which should it become necessary, could be adapted to working by induction (replacing simultaneously the fixed installations with batteries by others with electro-magnets).

Trials on a wider scale were therefore started in 1953 :

a) A trial equipment, supplied by another Company, working with a track contact was fitted in May 1953 on a type 101 electric locomotive.

b) Another trial was made at the same time with an equipment designed by the S.N.C.B., using a thyratron tube and a track contact. The functioning was satisfactory, but the system was given up on account of the following drawbacks : difficulty of supplying the thyratron filament, fragility of the tube, very variable sensitivity from one tube to another, sensitivity to outside ionisations.

c) The S.N.C.B. finally studied a new solution based on equipment already used on the rolling stock : track contact brush, speed recorder with compressed air whistle, dead man's handle device and pressure relay inserted in the control circuits. A trial was carried out in 1954 on a type 101 electric locomotive.

d) In 1953, ten type 101 locomotives were equipped with an automatic stopping device of the usual type but working by means of a track contact and capable of being adapted to working by induction.

e) A new order for 37 equipments all working by means of track contacts was placed in February 1955 in order to try it out on a wider scale on electric locomotives and diesel railcars.

f) Finally in 1957, for the reasons given below, the S.N.C.B. decided to extend to all its electric locomotives not yet equipped with an automatic stopping device (i.e. 201 rail motor coaches and 118 locomotives) the system quoted under heading *c*). The work involved in these modifications is still in hand.

2. Utility of devices which can be cancelled when running past a signal at danger.

All the above mentioned equipments have the drawback of it being possible for the driver to cancel their action when running past the warning signal, unless the speed has previously been reduced to a reasonable value and without affecting the braking of the train.

Such devices therefore do not assure complete safety.

On stock fitted with a speed recorder with whistle, their usefulness is debatable.

In fact should the driver run past a signal at danger or a signal ordering him to reduce speed without noticing it, the whistle of the speed recorder will call his attention to it and make him vigilant.

In every case in which the stopping device has to come into action, the warning whistle of the speed recorder will have sounded. Unless anything is wrong with him, the driver will stop the whistle just as he will cancel the working of the stopping device. After passing the warning signal, his reactions will not be influenced by one of these two operations any more than by the other. The reasons (faulty interpretation of the signal, confusion between two neighbouring signals) which led him — in very exceptional cases — not to take, in spite of the whistle, the steps he should have taken to respect the signal, will cause him to neglect to take the necessary safety measures after he has cancelled the working of the automatic stopping device.

It is therefore only when the driver is quite unconscious, when the whistle will continue to blow in vain, that the automatic stopping device, not having been cancelled, can make things safe by stopping the train, provided always that the dead man's handle has not already done so.

It can therefore be concluded that in the case of rolling stock fitted with a speed recorder with a warning whistle, the automatic stopping device which can be cancelled is simply an adjunct to the dead man's handle.

An examination of the statistics of serious accidents which occurred on the S.N.C.B. since 1950 shows that *none of these accidents could have been avoided* by an automatic stopping device that can be cancelled once the signal has been passed, but that some of them would have had less serious consequences had the stock been equipped with some device controlling the reactions of the driver *after* he had passed the warning signal.

Compared with devices working by means of a track contact, those working by induction have undoubtedly the advantage of greater safety of functioning; an examination of the same accident statistics shows, however, that faulty working of the speed recorder or one of the auxiliary components has never led to or aggravated any of these accidents.

This statement does not exclude the possibility of an accident occurring to which the faulty working of the dead man's handle, or the speed recorder, or its control by the track contact, has contributed; it appears however that the additional safety to be expected from the automatic stopping device that can be cancelled does not justify the considerable capital expenditure that it would entail.

It would appear preferable to look for increased safety not exclusively by perfecting the equipment until it can be relied upon to carry out impeccably a programme necessarily incomplete, but rather to improve at the same time the programme itself and its realisation.

For this reason the S.N.C.B. in 1957, whilst awaiting the perfecting of equipment to control the reactions of the driver after running past a warning signal, decided to generalize automatic stopping with possible cancellation in its most simple form.

The above reasoning does not necessarily apply to systems where locomotive cab signalling is not used in any form; although no statistics are available to confirm it, it appears certain that the speed recorder with warning whistle does avoid a certain number of accidents.

An administration which does not as yet make use of cab signalling, wishing to increase safety, may find it advantageous to apply repetition of the signals and automatic stopping simultaneously.

The application of equipment working by induction can only be justified after comparison of the additional cost of the installation with the greater security of functioning.

3. Necessity for controlling the reactions of the driver after running past a warning signal.

Since simple arrangements which can be cancelled are incapable of safeguarding trains from the consequences of mistakes or carelessness on the part of the staff, it is necessary to check the reactions of the latter after running past a warning signal at danger, and after cancelling the automatic stopping device.

Such a check can be made either by controlling the progressive reduction in speed, or by checking the position of certain brake components, or by a combination of both.

In what follows, we will deal above all with the first method which seems to be the most rational, whilst not departing from the principle of being able to introduce in the final programme a check of the position of the brake control components.

It will be noted in particular that the present study supposes that operating requirements concerning the regularity of the services are opposed to a systematic reduction in the speed after passing a warning signal at danger. A reference to the technical literature on this subject shows that most of the railway administrations admit this principle; it may happen, however, that whilst agreeing in *exceptional cases* to automatic braking which cannot be cancelled, the regularity of the service will not be too greatly endangered, and under these conditions the device required to obtain the desired degree of safety is considerably simplified. It is therefore important not to overlook this possibility.

The above mentioned two possibilities, i.e. the verification of the position of the control components of the brake, and automatic braking which cannot be cancelled in exceptional cases, should not however be considered unless a rational check of the speed after passing the warning signal cannot be realised economically. For this reason, these variations will not be gone into.

4. Programme for checking the speed at certain points between the warning signal and the stop signal.

In November 1956, the S.N.C.B. decided to study the effectiveness of checking the speed at certain points between the warning and stop signals.

The programme as first studied is explained below.

A. Passing a warning signal at line clear.

The stopping device does not come into play.

B. Passing a warning signal at danger (fig. 1).

The driver must work a vigilance (or cancellation) lever, otherwise the device applies the emergency brakes, and in any case he must reduce the speed of the train to 90 km/h. If after a given time *x* (expressed in seconds to be determined during the study), the speed is still more than 90 km/h the device will apply the emergency brakes; the checking of the speed after *x* is assured exclusively by apparatus fitted on the motor unit and is independent of the position of the stop signal since passing the warning signal.

If the driver sees that the stop signal is clear after passing the warning signal, he can regain his normal speed, *x* seconds after passing this warning signal.

If the stop signal remains at danger, a further check of the normal braking of the train is necessary at a lower speed. This additional check must depend upon the position of the signal and consequently involves additional fixed installations; it may be single or double, as the following report shows.

a) *Single additional check at 40 km/h.*

An additional check at 40 km/h makes it possible to increase the safety in the case of freight trains (which run at about 50 km/h) and passenger trains; on the other hand, it does not allow of a check on the braking for speed reductions, preceding a section on which the running is fixed at 40 km/h. This is not recommended, as such speed reductions when not respected may give rise to serious accidents.

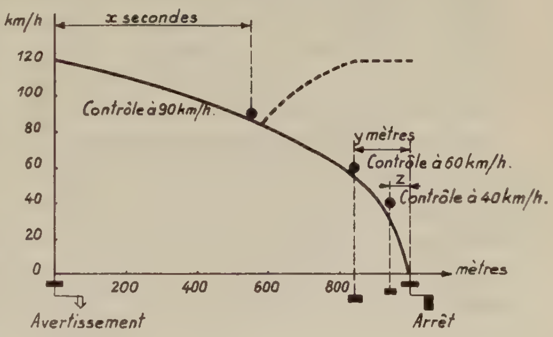


Fig. 1.

Translation of French wording :

x secondes = *x* seconds. — Contrôle à 90 km/h = Control at 90 km/h. — mètres = metres. — Avertissement = Warning. — Arrêt = Stop.

b) *Single additional check at 60 km/h.*

This allows of a check on the braking at speed reductions of 40 km/h; but allows of no check on freight trains (50 km/h).

In this latter case, it might be possible to fit a different interpretation on the rolling stock (for example by means of a « Freight-Passenger » switch).

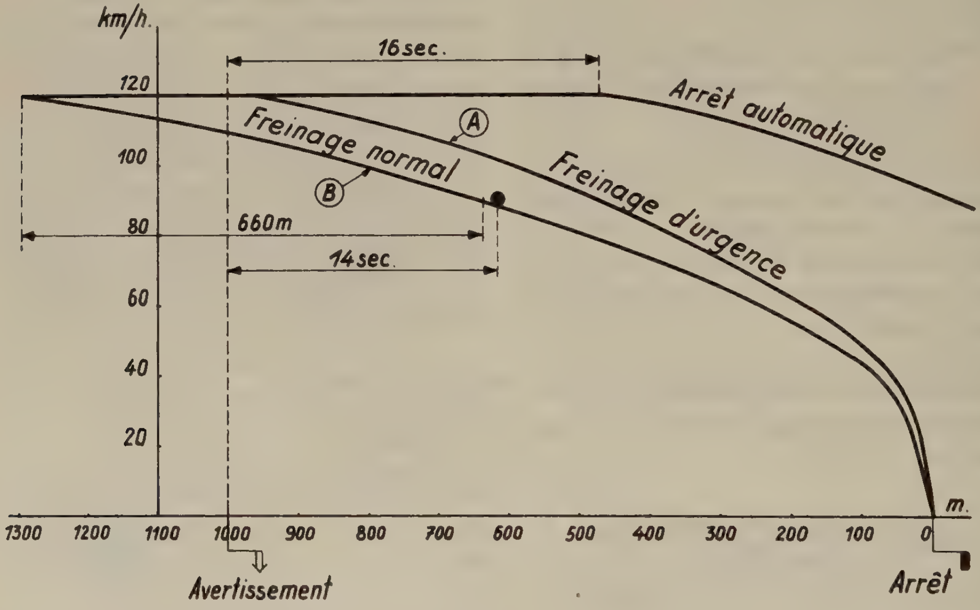


Fig. 2.

Translation of French wording:

Arrêt automatique = Automatic stop. — Freinage d'urgence = Emergency braking. — Freinage normal = Normal braking. Avertissement = Warning. — Arrêt = Stop.

c) *Double additional check of the braking* (fig. 1).

This check will take place between 60 and 40 km/h. In principle, it will make it possible to check the braking down to 40 km/h; it allows of checking both freight and passenger trains.

A final check of the running of the train will take place by the absolute stop signal; if this has been run past when at danger, the emergency brake will be applied and cannot be cancelled.

The system with crocodile contact is not suitable for transmitting with sufficient security the different indications from the track to the rolling stock.

It is supposed in what follows that the check is made by some system allowing of the certain transmission of a given number of different indications, which will be designated by the name « magnet » to simplify the report.

5. Effectiveness of checking the speed at certain points after the warning signal.

In order to determine the effectiveness of the check on the speed according to the programme described above, we must determine :

- The time *x* (in seconds) after which the speed of 90 km/h is to be checked;
- The distance in relation to the absolute stop signal;
  - Of the single check at 60 km/h;
  - Of the single check at 40 km/h;
  - Of the double check at 60 and 40 km/h.

In principle, these different factors must be determined in such a way as to assure the maximum safety, whilst avoiding any untoward working of the device when the driver brakes normally, the reduced speed of the train then being correct for obeying the indications of the signals.

Let us take as basis for our calculations a train consisting of 12 metal coaches with ordinary brake, hauled by an electric locomotive, also with ordinary brake; the curve of the emergency braking of such a train is shown in figure 2 (curve A).

The service braking obviously depends upon the action of the driver and can vary to a large extent; normal braking is generally considered to be that which reduces the speed by 75 % compared with the emergency braking.

Curve B of figure 2 shows the braking curve for braking under these conditions.

a) *Time* x *(in seconds) after which the speed of 90 km/h should be checked* (fig. 2).

Since the stopping distance at 120 km/h is 1 295 m, the driver should normally begin to apply his brakes 295 m before the warning signal (distance of repetition = 1 000 m); the speed will have fallen to 90 km/h after running 660 m, i.e. 365 m after the warning signal, which will have been passed 13.2 seconds ago.

The checking of the speed of 90 km/h can therefore take place 14 seconds after coming to the warning signal at the earliest.

Let us suppose however that after having recorded his vigilance the driver nevertheless continues to run at 120 km/h, so that the device will come into action 14 seconds after passing the warning signal and apply the emergency brakes; though with a certain time lag due to the functioning of the device (passive resistance of the rigging, propagation of the vacuum in the air pipes, etc...); if we allow for a delay of 2 seconds, we find that the emergency braking will in fact take place 16 seconds after passing the warning signal, i.e. 530 m after this signal.

Since the emergency braking distance to stop is equal to 970 m, the train will only come to a stop 1 500 m after the warning signal, i.e. 500 m after passing the stop signal.

If it is desired that the train should not run past the stop signal, the speed of 90 km/h must be checked by the warning signal itself; under these conditions, the driver would have to begin braking 660 m before the signal, to avoid the working of the device.

To obtain a stop in line with the absolute stop signal, the existence of such a device would then make it necessary to brake 365 m sooner than is normally necessary.

b) *Supplementary check at 60 km/h before the stop signal.*

Figure 3 shows that in order to allow the driver to brake normally, the check of the speed at 60 km/h must take place 225 m before the stop signal at least. If the driver has maintained his speed at 90 km/h the device will come into play at this point and will stop the train by means of the emergency brakes on a distance of 475 + 50 = 525 m (including a delay of 2 seconds in the functioning). The stop signal will be run past by 300 m.

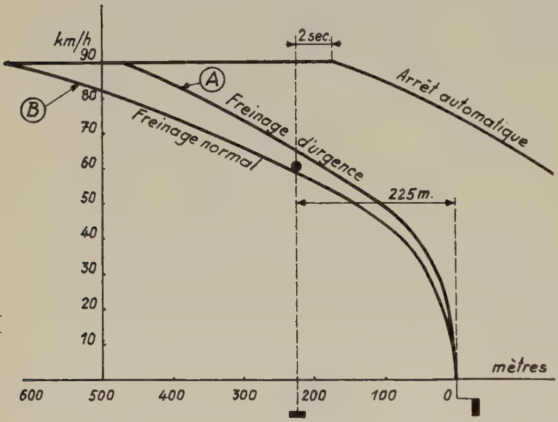


Fig. 3.

For the translation of the French wording, see Figure 2.

To avoid passing this signal, it would be necessary to check the speed of 60 km/h 525 m before the signal; in this case the driver would be obliged to run at this speed 300 m (= 525 — 225) sooner than is necessary with normal braking.

c) *Supplementary check at 40 km/h before a stop signal.*

The same reasons as those given under (b) above lead to the following conclusions:

To allow of a normal brake application, the check at 40 km/h must take place at only 50 m before the stop signal; if the driver is not on the alert, there is a risk of running past the signal :

- by 475 m (if there has been no supplementary check at 60 km/h);
- by 150 m (if a supplementary check has been made at 60 km/h).

To avoid passing the signal, it is necessary to force the driver to reduce his speed to 40 km/h at 200 m, or at 525 m before the stop signal (according to whether or not a supplementary check is made at 60 km/h).

d) *Supplementary check at 60 km/h before a section with a speed restriction of 20 km/h.*

To allow of normal braking, the check of the speed of 60 km/h must take place 210 m before the restricted speed section; if the driver is still running at 90 km/h, the device will apply the emergency brakes, but the train will still run into the restricted speed section at 76 km/h.

6. Need to look for improvements.

The above considerations make it apparent that checking the braking at several points (even with a system with 4 indications and checks at 90, 60 and 40 km/h does not assure complete safety.

7. Remarks.

a) On most railways, the absolute stop signal is installed a certain distance before the danger point; in several of the cases considered above, the train would only stop after the stop signal, at a distance considerably exceeding the distance usually chosen for safety reasons between the signal and the danger point. To increase this distance cannot be considered in practice, in view of some technical impossibility or of the enormous capital expenditure involved.

b) It may seem most unlikely that a driver after cancelling the automatic stopping device when running past a warning signal at danger, would continue to run without reducing the speed of the train. It may happen however that exceptional circumstances may lead the driver to think, soon after passing the warning signal, that the stop signal is at line clear, thus causing him to release his brakes and even get up speed again.

c) The above calculations were made for unfavourable conditions; unlike devices that can be cancelled purely and simply, devices which check the braking at various points, may possibly avoid certain accidents, or at least reduce their consequences.

An examination of the accident statistics showed that only one of the accidents which have occurred on the S.N.C.B. since 1950 would have been avoided; in the other cases, the consequences might have been reduced, but it is difficult to estimate to what extent.

8. Justification for the programme.

The application of automatic stopping devices with checks of the braking at various points involves considerable capital expenditure; consequently, it is disquieting to think that accidents may still occur owing to a wrong interpretation of the signal indications.

If better systems can be perfected in the near future, it would doubtless be difficult to justify altering the existing devices.

It is therefore preferable :

- To investigate above all the ideal programme;
- To check whether it would be possible to realise it technically;
- To examine up to what point improvements would be economically justified, and therefore decide the programme to be followed in the immediate future, whilst safeguarding the possibility of further improvements.

The first two points of these investigations are the subject of the 2nd and 3rd parts of this article respectively.

The final point remains to be examined.

* * *

PART II

ASCERTAINING THE IDEAL PROGRAMME

9. General study of possibilities of control.

As paragraph 5 makes clear, checking the braking at three points (90, 60, and 40 km/h) is not sufficient, and it is necessary to investigate methodically how many checks are needed to assure complete safety.

Before beginning this study, it is necessary to verify under what form the variable parameters (speed V, distance run l and time t) are to be considered in the check on the braking, so that this shall take place in the most rational way.

These three parameters can be combined in pairs (the third being determined by the two others); checking one factor as a function of the other in theory allows of 6 methods :

- Checking V as a function of t ;
- Checking t as a function of V;
- Checking V as a function of l ;
- Checking l as a function of V;
- Checking l as a function of t ;
- Checking t as a function of l ;

Such checks can be made either on the total values from the point X (where normal braking should begin, i.e. at the warning signal), or on the variations in these values from the previous check. This gives 12 possible methods :

a) Checking the instantaneous speed after x_1, x_2, x_3 ... seconds;

b) Checking the variation in the speed between x_n and x_{n-1} seconds;

c) Checking the time from point X to bring down the speed to V 1, V 2, ... km/h;

d) Checking the time required to reduce the speed from V_{n-1} to V_n;

e) Checking the instantaneous speed after l_1, l_2, l_3, ... metres;

f) Checking the variation in speed between l_n and l_{n-1} metres;

g) Checking the distance run from point X whilst reducing the speed to V 1, V 2, ... km/h;

h) Checking the distance run to reduce the speed from V_{n-1} to V_n;

i) Checking the distance run after x_1, x_2, x_3, ... seconds;

j) Checking the distance run between x_n and x_{n-1} seconds;

k) Checking the time required to run l_1, l_2, l_3, ... metres;

l) Checking the time required to run $(l_n - l_{n-1})$ metres;

Most of these methods will have to be eliminated for the reasons given below.

10. Methods of checking to be eliminated.

Let us take the case of a train made up of stock which can run at 120 km/h with an emergency braking curve on the level shown in figure 4. To simplify the report we will take the braking distance to a stop as equal to the distance between the warning signal and stop signal (1 000 m).

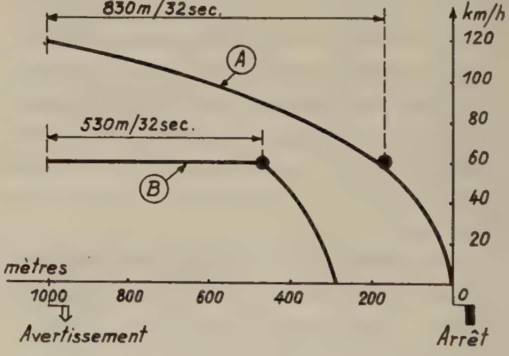


Fig. 4.

Translation of French wording :
Avertissement = Warning. — Arrêt = Stop.

We will take it that the number of checks is so great that they can occur on the emergency braking curve itself (leaving aside the delay due to the working of the device).

To simplify the report we will designate the different methods by the letter allocated them in the previous paragraph.

a) *Checking the instantaneous speed after* x_1, x_2, x_3, ... *seconds.*

On figure 4, we see (curve A) that the check made at 60 km/h for example must take place 32 seconds after passing the warning signal.

Let us now suppose (curve B) that a train is really running at 60 km/h (16.6 m/sec). The check of the speed of 60 km/h will then take place at a distance of (16.6 m/sec × 32 sec) = 530 m after the warning signal, whereas it was the intention to check this speed only at 830 m beyond this signal. After this point the driver is obliged to slow down his train, whereas normally he could still run 300 m at this speed without having to brake.

b) *Checking the variation in the speed (deceleration) between* x_n *and* x_{n-1} *seconds.*

This method must be rejected as if the train passes at a reduced speed at a point N, there can be no need to carry out a check of its deceleration.

c) *Checking the time needed, after passing the warning signal, to reduce the speed successively to V 1, V 2, ... km/h.*

This check is a negative one, as if the speed is maintained constant at a given value, the time checked is infinite and the device will never have to intervene.

It is possible to make the device function at the moment when the time already measured reaches a certain value; this however will always correspond to the method given under a).

d) *Checking the time needed to reduce the speed from* V_{n-1} *to* V_n.

This method must be rejected for the same reasons as c) above.

f) *Checking the variation in speed between* l_n and l_{n-1} *metres.*

This method must be rejected for the reasons given under b) above.

g) *Checking the distance run after the warning signal before the speed is reduced to V 1, V 2, ... km/h.*

This method must be rejected for the reasons given under heading c) above.

h) *Checking the distance run in order to reduce the speed from* V_{n-1} *to* V_n *km/h.*

This method must be rejected for the reasons given under heading c) above.

i) *Checking the distance run after* x_1, x_2 ... *seconds.*

We find in particular (curve A of fig. 5) that a check after 50 seconds allows a distance of 1 000 m.

Now, if a train passes the warning signal at 70 km/h (curve B) and maintains this speed, it will only have run 975 m after 50 seconds; the equipment will not work, and the stop signal will be passed at a speed of about 70 km/h.

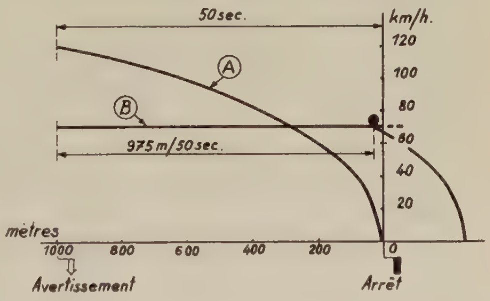


Fig. 5.

Translation of French wording :
Avertissement = Warning. — Arrêt = Stop.

This method therefore must be rejected.

j) *Checking the distance run between* x$_n$ and x$_{n-1}$ *seconds.*

Measuring the space run during a short period of time is the same as measuring the speed.

This case can be compared with heading a) above.

k) *Checking the time required to run* l_1, l_2 ... *metres.*

This case can be compared with heading h) above.

This leaves us finally with two methods to be gone into further (*e* and *l*) of paragraph 9).

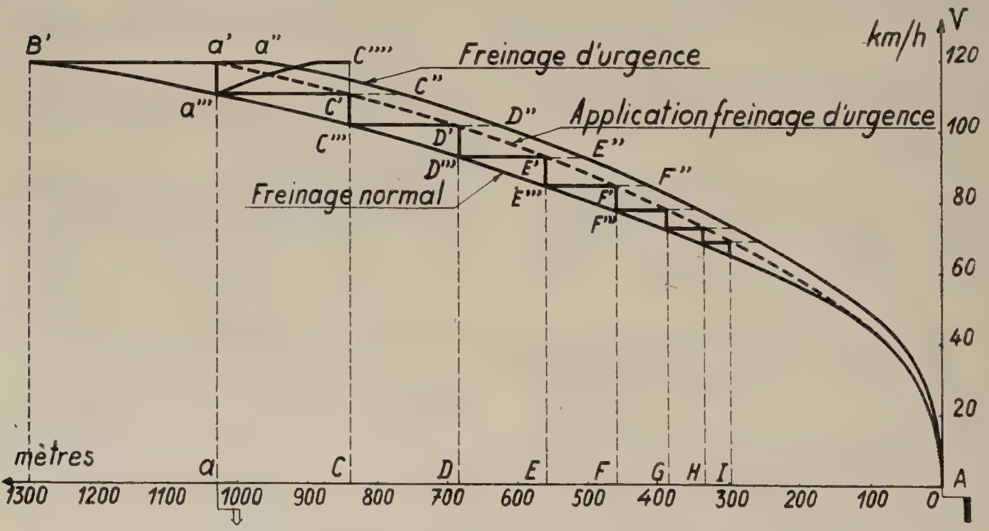


Fig. 6.

Translation of French wording :

Freinage d'urgence = Emergency braking. — Application freinage d'urgence = Emergency braking applied. — Freinage normal = Standard braking.

11. Basic factors of a through study of rational control.

Let us consider (fig. 6) a warning signal (*a*) and a stop signal (A).

Let us draw for a passenger train of 12 metal coaches with ordinary brake hauled by an electric locomotive, also with ordinary brake :

- The normal braking curve corresponding to a stop at A;
- The emergency braking curve corresponding to a stop at A;
- The curve (« emergency brake application ») which shows for each speed the point at which the device causing the emergency brakes to be applied must act if the train is to stop at A (the curve « Emergency brake application » is set off compared with the emergency braking curve by a distance which corresponds to a delay of 2 seconds in the functioning of the device).

To simplify the report, we have allowed for a distance of 1 030 m between the warning signal (*a*) and the stop signal (A), i.e. the distance in which the working of the device can just stop a train running at 120 km/h at A.

It is necessary to determine the checks to be made if safety is to be completely assured (signal A not run past).

12. Number of checks of the instantaneous speed after l_1, l_2, l_3 ... metres needed to stop the train every time before or at the stop signal.

A. First check.

a) *Hypothesis 1.*

The driver is not paying attention and passes the warning signal at 120 km/h.

The automatic stopping device must apply the emergency brakes instantaneously; the train is stopped at A (speed curve B′ *a*″ A).

b) *Hypothesis 2.*

The driver is paying attention and applies his brakes normally as from B.

He drops at (*a*) to 111 km/h, and can stop at A (speed curve B′ *a*‴ C‴ D‴ E‴ F‴ ... A).

There must therefore be a check at (*a*) that the speed of the train does not exceed 111 km/h and this is sufficient.

In effect, if it was equal to 120 km/h (maximum speed authorised on the line), the emergency braking would still stop the train at A.

B. Second check.

a) *Hypothesis 1.*

At (*a*) the train passed at 111 km/h (so that the automatic train stopping device did not function), but this speed was wrongly maintained (speed curve B′ *a*‴ C′).

If the emergency brakes are applied instantaneously at C, safety is assured (speed curve B′ *a*‴ C′ C″ D″ E″ F″ ... A).

b) *Hypothesis 2.*

At C the train passed at 102 km/h (ordinary braking) and the train can stop at A (speed curve C‴, D‴ ... A).

At C therefore it is only necessary to check that the train speed does not exceed 102 km/h.

C. Third check.

a) *Hypothesis 1.*

At C the train passes at 102 km/h (so that the 2nd check did not intervene), but this speed is maintained.

If emergency braking is applied instantaneously at D, safety is assured (speed curve C‴ D′ D″ E″ ... A).

b) *Hypothesis 2.*

At D the train passes at about 93 km/h (ordinary braking) and the train can stop at A (speed curve D‴ E‴ ... A).

It is therefore necessary to check at D that the speed of the train does not exceed 93 km/h.

D. Fourth check.

By the same reasoning as above, it can be shown that a check must be made at E that the speed of the train does not exceed 85 km/h (approx.).

E. Fifth check, etc.

Figure 6 shows that it is also necessary to check successively at F, G, H, I ... that the speed of the train does not exceed respectively 78, 73, 69, 65 km/h.

On the other hand, we find that after 60 km/h the braking curves come together and the number of checks becomes so great that control of the braking is practically continuous.

13. Number of checks of the instantaneous speed after l_1, l_2, l_3, ... metres required to stop the train within the 100 m after the stop signal.

Figure 7 represents the same study in the hypothesis that the device stops the train within the 100 m after the stop signal.

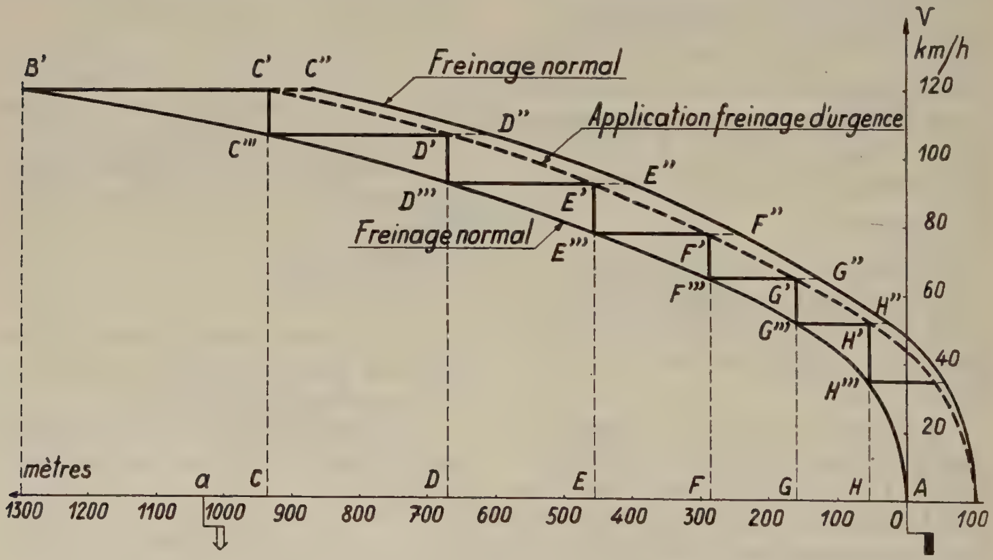


Fig. 7.

Note : Translation of French wording, see Figure 6.

We find that in this case, 7 checks (at C, D, E, F, G, H, and A) respectively at speeds of 107, 92, 78, 65, 52 and 35 km/h are sufficient. At point A the emergency brakes have to be applied no matter what the speed.

14. Application.

In the stopping devices with checks of the braking that we know of, each supplementary check of the speed only occurs provided the signal is still at danger; each check consequently involves a supplementary track installation in relation with the position of the signal.

If, in order to obtain complete safety, the number of checks is great (see report under paragraphs 12 and 13), it appears economically impossible to multiply the track installations to the same extent.

Consequently a new method becomes necessary. The arguments of paragraphs 12 and 13 might be applied as follows.

The train passes (*a*) at a speed slightly below 111 km/h.

The motor unit receives there an impulsion which starts up a totalisator of the distance travelled.

After running a distance equal to *a*C, the speed V is checked.

If V > 102 km/h, automatic stop.

If V < 102 km/h, the totalisator continues to work and after running an additional distance CD, the speed is checked again.

If V > 93 km/h, automatic stop.

If V < 93 km/h, the totalisator continues to work ... etc.

If cancellation is not authorised (i.e. as soon as a warning signal at danger is passed, the train must be braked down to 20 km/h for example), only one track equipment is required (in line with the warning signal).

If it is desired to be able to cancel the system (stop signal goes to line clear after the warning signal has been run past at danger), one or more supplementary track magnets are necessary, installed between the warning and stop signals, which as soon as they are passed once the signal has gone back to line clear, automatically cancel the control of the braking.

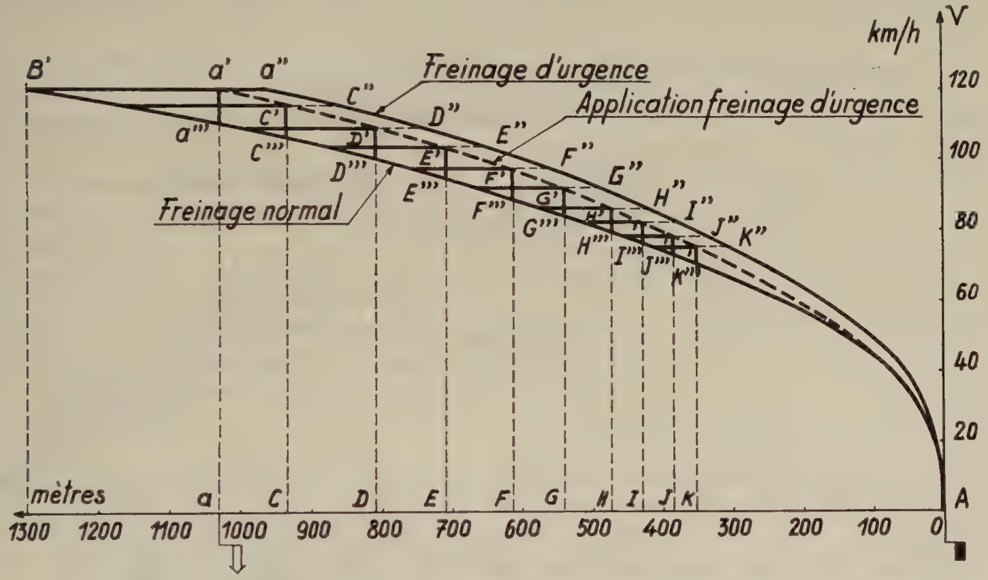


Fig. 8.

Note : Translation of French wording, see Figure 6.

After a certain speed (for example 20 km/h) the control of the braking ceases. If the train runs past the stop signal, the emergency braking comes into action and cannot be cut out, and the train stops within 10 to 20 m.

Such a system would practically prevent any accident due to faulty interpretation of the signal indications.

15. Note.

It has been supposed (fig. 6) that the driver has made the mistake of maintaining his speed constant after a given moment. It might be feared however that when he has mistaken the position of the signal, the driver will regain speed immediately after he has taken off the brakes.

Obviously under these conditions, it would be impossible to stop before signal A (for ex. if the speed curve after *a* became *a'''* C'''') (fig. 6).

The control of the braking must always be accompanied with automatic cutting out of the tractive effort (after point *a* up to possible cancellation of the control of the braking).

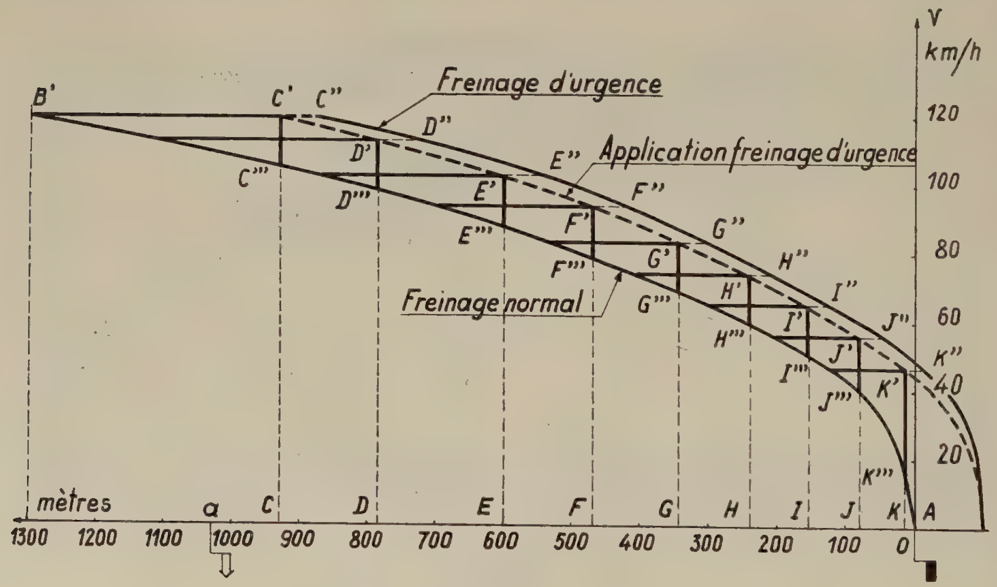


Fig. 9.

Note : Translation of French wording, see Figure 6.

16. Check of the time needed to run (l_n — l_{n-1}) metres.

In paragraph 10, we came to the conclusion that there remained two systems which should be gone into. The first system, that of checking the instantaneous speed after l_1, l_2, l_3 ... metres has been examined in paragraphs 12 to 14.

There remains to examine the system of checking the time needed to run (l_n — l_{n-1}) metres.

Reasoning on identical lines to paragraphs 12 and 13, we can establish the graphs of figure 8 and 9 (requiring respectively a stop at signal A, or at the most 100 m beyond it).

By measuring the time needed to run (l_n — l_{n-1}) m, we are in reality checking the average speed between two check points.

It is necessary that after just avoiding making the device function at the check C*n* (maintaining the speed at the average of the checks C*n* and C*n*—1), the functioning at C*n* + 1 stops the train.

The checks to be made to assure stopping at signal A are as follows (fig. 8) :

— At *a* : 8.5 seconds from point B,
— At C : 3.2 seconds from point *a*,
— At D : 4.35 seconds after point C,
— At E : 3.7 seconds after point D,
— At F : 3.7 seconds after point E,
— At G : 3.15 seconds after point F,
— At H : 2.85 seconds after point G,
— At I : 2.1 seconds after point H,
— At J : 1.9 seconds after point I,
— At K : 1.75 seconds after point J.

We find that below 70 km/h, the brake curves become so close to each other and the number of checks increases to such a point that checking the braking has to be practically continuous.

The checks to be made to assure stopping within 100 m after signal A are the following (fig. 9) :

— At C : 11.6 seconds from point B,
— At D : 4.9 seconds from point C,
— At E : 7.3 seconds after point D,
— At F : 5.6 seconds after point E,
— At G : 6.1 seconds after point F,
— At H : 5.8 seconds after point G,
— At I : 5.45 seconds after point H,
— At J : 5.8 seconds after point I,
— At K : 8.35 seconds after point J,
— At A : emergency braking in all cases.

17. Comparison of the methods described in paragraphs 12 and 13 on the one hand and paragraph 16 on the other hand.

The first method requires fewer check points.

At first sight, the second method seems to be easier to apply, as it is more convenient to measure time than speed.

It should however be noted that the measurement of the time inevitably gives rise to mistakes (especially when it is necessary to measure fractions of a second), and that the consequences of such errors are much greater than a mistake made in measuring the speed.

In addition, if the number of check points is increased until there is practically continuous control (see paragraph 18), the two methods are equivalent and only differ from each other by the way in which the speed is measured technically.

18. Checking the braking continuously or almost continuously.

In paragraph 14. it has been shown that, taking into account the great number of checks that have to be made to assure complete safety, such checks can no longer be made by means of track magnets, but should be done by a « totalisor of the distance covered » installed on the locomotive.

Under these conditions, it does not appear difficult to increase the number of checks until there is continuous or almost continuous control. This solution has the advantage of making the control curve approximate to that of the emergency braking, thus allowing the driver greater liberty in normal braking.

Starting from this idea, it is possible to establish a first programme for making a stop device with continuous control of the braking according to a *single predetermined curve*.

An impulsion emitted or checked by a track magnet fitted by the warning signal puts the device into action when this signal is at danger.

The electric traction circuits must be broken immediately.

If the driver does not furnish proof of his vigilance, the emergency braking immediately comes into play.

If the driver proves his vigilance, the emergency braking does not come into play, but the normal braking of the train is checked, by continuously checking the speed as a function of the distance covered according to a predetermined curve. Emergency braking comes into play automatically as soon as the actual speed exceeds the maximum speed authorised at this point according to the control curve (a second needle on the speedometer would enable the driver to check at each moment that his braking complies with the limits authorised and enables him to avoid the intervention of the device).

The device intervenes as soon as the speed of the train exceeds at any given moment on the run the maximum speed authorised.

One or two track magnets installed between the warning signal and the stop signal can assure automatically cancellation of the functioning of the device if the signal is put to line clear as the train passes.

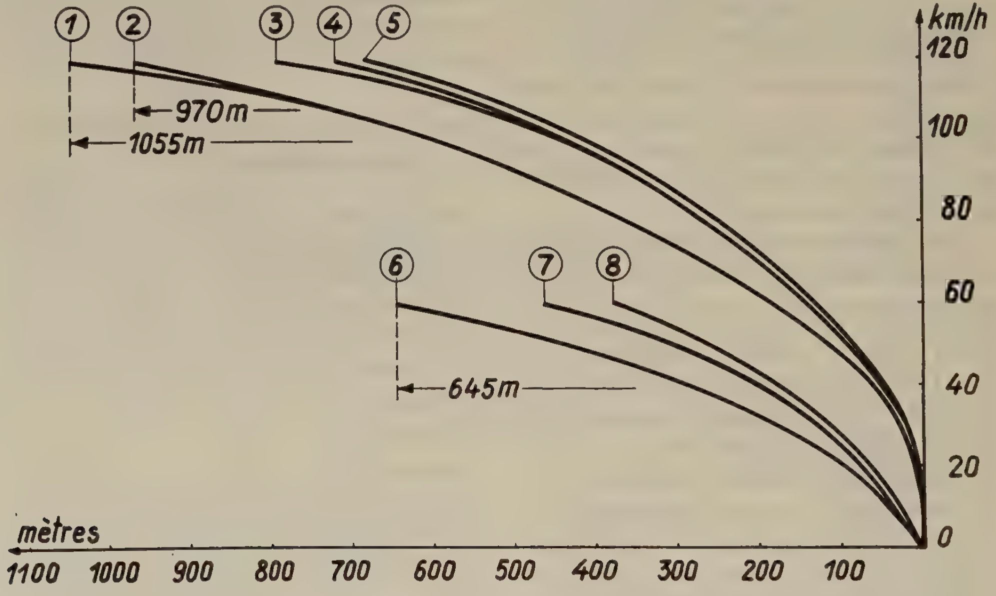


Fig. 10.

When the train has been slowed down to 20 km/h, the driver can continue to run at this speed, on condition that he has again proved his vigilance; in any case the speed of the train cannot exceed 20 km/h until it has run past a magnet cancelling the device; running past an absolute stop signal causes the emergency braking to operate irrevocably.

19. Disadvantages of a programme of continuous control from a single given curve.

Even if technically realisable, a device assuring the programme given in paragraph 18 would still not entirely satisfy operating requirements and could not be applied as such.

The following considerations must be taken into account :

a) The form of the braking curve (speed as a function of the distance travelled) varies as a function of the following factors :

- kind of train (passenger, freight, use of auto-variable brake);
- gradients on the line;
- coefficient of braking of the train.

b) The distance between the warning signal and the absolute stop signal is modified to a certain extent as a function of the profile of the line.

c) The measurement of the speeds and distances travelled is affected by the wear of the wheel tyres.

d) The device must also make it possible to check if the speed limits imposed by the signals are respected, and if the braking before the restricted speed sections is correctly done.

We will consider in turn each of these points.

20. Kind of train.

By applying the classic formulae to the extreme cases met with in electric traction, we get the braking curves on the level shown in figure 10.

These correspond to the following cases :

1. Rail motor coach with 8 coaches — ordinary brake;
2. Rail motor coach with 2 coaches — ordinary brake.
   Electric locomotive + 4 to 12 coaches — ordinary brake;
3. Rail motor coach of 8 coaches — autovariable brake;
4. Rail motor coach of 2 coaches — autovariable brake;
   Electric locomotive + 4 coaches — autovariable brake;
5. Electric locomotives + 12 coaches — autovariable brake;
6. Freight train : 30 % of the weight braked;
7. Freight train : 50 % of the weight braked;
8. Freight train : 70 % of the weight braked.

It will be seen that the braking distances are very varied according to the type of train.

A priori, this is annoying, as in the theory given above, the actual running of the train must be compared with a theoretical curve.

It is therefore necessary to have devices with different theoretical curves incorporated.

a) In the case of *rail motor coaches*, the theoretical curve to be incorporated must be that corresponding to an emergency braking distance on the level of 1 055 m (most unfavourable case for a rail motor coach with 8 coaches with ordinary brake). In the case of trains with better braking, the device will force the driver to brake slightly sooner than necessary (in the case of a train of 2 coaches with high power brake for example, the control will be according to a braking curve with a deceleration equal to 68 % of that of the emergency braking curve of the train in question).

b) In the case of mixed traffic locomotives, it must be possible to modify the theoretical curve incorporated easily.

— In the case of passenger trains, this curve must correspond to a braking distance (emergency) on the level from 120 km/h equal to 970 m (most unfavourable case : electric locomotive and 4 to 12 coaches, all with ordinary brakes); in the case of trains with high power brakes, the control curve will show a deceleration equal to 70 % of that of the emergency braking curve.

— In the case of freight trains, the control curve must correspond to an emergency braking distance on the level from 60 km/h equal to 645 m (braking percentage equal to 30 %). If the train has a higher braking percentage than 30 %, the device will oblige the driver to brake all the same, just as if the percentage was no higher than 30 %.

The modification of the theoretical curve incorporated might be by means of a switch combined with the commutator of the braking regime; in the freight position, the speed during the run can never exceed 60 km/h without the device coming into play.

To prevent the driver leaving the switch (on purpose or not) in the « passenger » position, even on freight trains, an indication of the position of the switch might be given on the recorder strip; this would enable systematic checking to be made, but would not assure the complete safety of freight trains.

It is therefore desirable to find some method of preventing mechanically the switch controlling the braking regime being left in the passenger position when hauling freight trains.

21. Note.

Although it is possible to carry out on the motor unit, control of the braking according to a different theoretical curve for different types of rolling stock, it is obvious that the distance between the warning magnet and the stop signal must be the same for all the trains. To obtain complete safety, on the level this distance must always be 1 055 m (most unfavourable case of a rail motor unit of 8 coaches with ordinary brake).

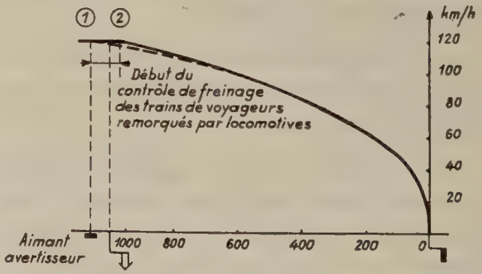


Fig. 11.

Début du contrôle de freinage des trains de voyageurs remorqués par locomotives = Start of the control braking of passenger trains hauled by locomotives. — Aimant avertisseur = Warning magnet.

For other types of trains, fitted according to a different theoretical incorporated curve, the control of the braking must only begin a certain distance after the warning magnet (fig. 11).

22. Up or down gradients on the line.

For the different types of trains considered in the previous paragraph, the braking curves have been calculated for up and down gradients of 0, 4, 8, 12 and 16 mm per metre.

The lines of these curves show that for the same type of train, the braking distances vary according to the gradient to such an extent that a device controlling the braking according to a predetermined curve could never be satisfactory in service.

It is therefore necessary to modify the incorporated theoretical curve according to the down gradients of the section on which the train runs; the indication of the necessary inclination to make this modification to the theoretical curve can only be obtained from the line itself and therefore involves a further fixed installation. (It would appear that it is not possible to use pendulums indicating up and down gradients fitted on the locomotive owing to the accelerations and vibrations).

This installation must allow of the transmission of a great number of indications (for example : level, up gradients of 8 or 16 mm/m, down gradients of 4, 8, 12 or 16 mm/m. It does not appear that « magnets » could be designed which would allow of the transmission of so many indications, and it would appear to be easier to measure the gradient of the line by the *distance* between two magnets, one of which could be the magnet fitted by the warning signal, which we will call the « braking magnet » and the other we will call « the gradient magnet ».

In principle, the gradient magnet could be before or after the braking magnet.

It is better for the indication given by the gradient magnet to be independent of the position of the signal. In effect, if this magnet merely transmits the indication when the signal is at danger, there is a risk of discordancy between the indications of the two magnets, the position of the signal having changed since one or other of them was run past.

The indication given by the gradient magnet being independent of the position of the signal, it is preferable for this magnet to be installed after the braking magnet, so as to record the indication of the gradient magnet on the rolling stock after the braking indication has been received.

In the third part of this study, we take it therefore that gradient magnets independent of the position of the signal, installed beyond the braking magnets are used. The control of the braking will take place to begin with according to a curve which possibly may not correspond completely to the profile of the line, but the slight error can be made good in the other part of the control curve.

23. Note.

By reasoning similar to that made in the note after paragraph 21, it can be shown that the distance between the braking magnet and the stop signal should always be equal to the braking distance of the most poorly braked train on the gradient in question.

For other types of trains, for which the device will be fitted with a different incorporated theoretical curve, the control of the braking will only begin after the braking magnet, at a distance depending on the down gradient.

24. Influence of the wear of the tyres.

Generally, the indications given by the speed recorder are only accurate when the diameter of the wheels equals its average value. When the wheels are new, the diameter is x % greater and the real speed VMR corresponding to the indication VM (maximum speed authorised) of the speed recorder will equal to :

$$V_{MR} = V_M \, (1 + 0.01 \, x).$$

If we call the average braking deceleration (a) on the level for a given train, we can write for the braking on an up or down gradient of i mm/m that :

$$V = (a \pm i) \, t.$$

$$l = \frac{(a \pm i) \, t^2}{2} = \frac{V^2}{2 \, (a \pm i)}$$

If l_M is the stopping distance from a speed of V_M in the case of the given train, on the gradient in question, the stopping distance from the real maximum speed V_{MR} ($= (1 + 0.01 \, x) \, V_M$) will therefore be $l_{MR} = l_M \, (1 + 0.01 \, x)^2 \approx l_M \, (1 + 0.02 \, x)$.

In order that the train can always stop before the stop signal, the distance between the braking magnet and the stop signal must be increased (see remarks in paragraphs 20 and 23) by $2 \, x$ % (i.e. 9 % in the particular case of 8 coach rail motor coaches of the S.N.C.B. — diameter of the wheels : 1 118 to 1 026 mm according to whether the tyres are new or worn — (fig. 12).

The theoretical curves incorporated in the stopping devices must naturally be adapted to this, and their stopping distance must also be increased by $2 \, x$ %.

Let us now suppose that a train with worn tyres approaches the signal : the stopping device will measure the distance which is x % greater than the real distance and cause the stop to be made at $0.01 \, x \cdot l_{MR}$ metres before the signal.

On the other hand, if the wheels were new, the device would measure a distance which is x % smaller than the real distance and cause the stop signal to be passed by $0.01 \, x \, l_{MR}$ metres (fig. 12).

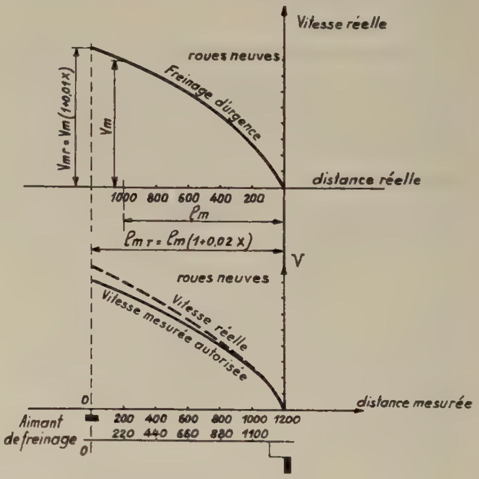


Fig. 12.

Translation of French wording ;

Roues neuves = New wheels. — Vitesse réelle = Real speed. — Freinage d'urgence = Emergency braking. — Distance réelle = Real distance. — Vitesse mesurée autorisée = Authorised measured speed. — Distance mesurée = Measured distance. — Aimant de freinage = Braking magnet.

Consequently, it is necessary for the device to authorise a *measured* braking distance which is the greater as the diameter of the wheels is the smaller.

On the other hand, the diameter of the wheels also influences the measurement of the distance between the braking magnet and the gradient magnet, the distance which measures the gradient, and consequently the stopping distance required; with a smaller diameter the device will measure too great a distance.

In order that this latter error shall compensate the former, it is therefore necessary for the greatest distance between the braking magnet and the gradient magnet to be the measurement of the steepest gradient; in this case, in effect, with too small a diameter, the gradient will be measured too steep, which will mean a greater (measured) braking distance.

It can be shown that for this compensation to be complete, it is necessary for the distance between the braking magnet and the gradient magnet to be *proportional* to the emergency braking distance (of the worst braked train for example).

Taking a ratio of 1/7, it can be concluded that the distance between the two magnets should vary between :

— 120 m for an up gradient of 16 mm/m and

— 200 m for a down gradient of 16 mm/m.

25. Combined signals.

With Belgian signalling, a combined signal can give one of the following indications :

a) Signal at danger : imposing an absolute stop.

b) Signal at line clear, but following signal at danger; requiring the speed to be reduced.

c) Line clear without restriction.

If the distance between the combined signal and the stop signal beyond is less than the stopping distance, the braking magnet must be installed before the combined signal; the stop magnet cannot however be advanced, as the signal is not always visible sufficiently far off.

In this case, if a train has been held at the foot of the combined signal (at stop) and the signal is put at line clear (the following signal still being at stop) the stop magnet must be freed, but a new check of the running of the train must take place according to a curve the *origin of which must necessarily have been recorded*, by the braking magnet, i.e. *before the cancellation at the combined signal of the preceding check.*

This means that the equipment on the locomotive must be so designed that it can proceed simultaneously according to the lines of two successive braking curves, only the first of which controls the running of the train; the cancellation must always take place on the first curve recorded, and should automatically transfer the control of the running of the train to the second curve recorded.

26. Sections with speed restrictions.

In the above paragraphs, we have examined the conditions to be imposed on a programme for controlling the braking before an absolute stop signal. The statistics show that a considerable percentage of the serious accidents which occur can be attributed to excessive speed in sections where there is a speed restriction.

The control of the *braking* on slowing down can be done in the same way as that of braking to a stop; but instead of continuing the control to a stop, it must only continue until the section with the speed restrictions has been entered at the speed prescribed.

At this point a track equipment should cancel the control of the braking and replace it by control of the speed : in view of the fairly wide scale of speed limits, this track equipment should allow of the transmission of a large number of indications and cannot be realised by means of a single magnet.

Theoretically, it is possible to imagine that it would be sufficient to put a single magnet at the point where the speed on the controlled braking curve reaches that authorised in the restricted speed section. The equipment on the locomotive would simply make sure that this speed was maintained. It must however be pointed out that this solution is not always applicable because in certain cases, very small differences in the measurement of the distances may lead to too serious errors in the speeds imposed (the braking curve becoming very steep at speeds below 40 km/h).

It is therefore indicated to measure the authorised speed by the distance between two track magnets.

In addition, it is necessary to make a distinction between two categories of speed restrictions :

a) Permanent restrictions, over fairly long distances, which have been taken into account in siting the signals (smaller distances between signals);

b) Temporary restrictions which do not affect the siting of the signals.

In what follows, we will call these two categories of speed restrictions respectively « permanent restrictions » and « temporary restrictions » (although in certain cases, the latter may have a « permanent » character in the sense given to this term in certain signalling regulations).

In both cases, the speed authorised by the device must be reduced, and running from a section with normal speed to a restricted speed section must be accompanied by a check of the braking, controlled by a magnet which can be of the same type as that of the warning signals (accompanied by a « gradient magnet »).

In the case of a permanent restriction, the control of the reduced speed must be realised in such a way that all the subsequent checks of the braking in the section in question follow a curve which begins (at the braking magnet) *at the reduced speed imposed by the permanent restriction in question.* (i.e. after a reduced braking distance).

In the case of a temporary restriction on the other hand, the check of the reduced speed must be made in such a way that subsequent checks of the braking in the section in question will continue to be based on a curve which begins (at the braking magnet) *at the normal speed on the line.* In the first part of the curve, there is in fact only a virtual check, since the speed authorised by this curve is higher than that authorised by the temporary restriction.

It results from the above that three types of speed restriction magnet are needed :

— Permanent speed reduction magnets;
— Temporary speed reduction magnets;
— A magnet, which on account of its distance compared with a magnet of one of the above 2 types, will fix the authorised speed.

It is obvious that magnets of distinct types have to be available for cancelling the permanent restrictions on the one hand and the temporary restrictions on the other (case of cancelling a temporary restriction for work on the line for example within a section with a permanent speed restriction which has to be maintained).

To sum up, each speed restricted section (permanent or temporary) will be equipped with a series of magnets :

— Braking magnet;

— Gradient magnet;

— Speed restriction magnet (permanent or temporary);

— Speed magnet : the reception of this indication on the locomotive must automatically cancel the braking control and substitute a control of the speed (control realised differently according to whether it is question of a permanent or temporary restriction);

— Magnet for cancelling the speed restriction (permanent or temporary).

It results from the above, that braking on account of speed restrictions (depending upon the distance between its braking magnet and its speed magnet) can never be sited, entirely within the braking area of a stop signal. In effect, since cancellation always takes place upon the first curve recorded (see paragraph 25), the indication given by the speed magnet will cancel the braking to a stop, whereas it was intended to cancel the braking for the speed restriction. Should such a case occur, it would be necessary either to advance the restricted speed section so that its braking magnet would be installed before that of the warning signal, or to put back the restricted speed section so that its speed magnet could be sited after the stop signal.

It may be asked whether the speed restriction magnets (permanent or temporary) could not of themselves check the braking, so as to save having a braking magnet. Although such a possibility is not excluded a priori, we are afraid that it would lead to complications in the equipment on the locomotive, because the braking distance is influenced by the gradient, whereas the measurement of the speed should not be influenced by it. Now, the speed magnet has to be placed at the beginning of the restricted speed section, and it would be impossible without undue complications always to put the speed restriction magnet at the actual point at which braking should begin.

In the third part of this study we do not consider this possibility, and we deal with the programme as laid down in the first part of the study.

27. Conclusions and ideal programme.

We can conclude from what has been said above that to meet all the operating conditions required, the programme reported in paragraph 18 with control of the braking according to a single incorporated theoretical curve must be completed as follows :

a) The « incorporated theoretical curve » for rail motor coaches must be different from that for locomotives. On the latter, it must be possible to modify the curve according to whether the locomotive is hauling a passenger or a freight train; for each of the three cases the control curve must be the emergency braking curve for the worst braked train of the category.

b) The braking magnet must be placed before the stop signal, and at a distance equal to the real emergency braking distance, on the gradient in question, of the worst braked train (8 coach rail motor train with ordinary brake), from the real speed corresponding to the indication V max. of the speed recorder, taking it that the wheels are new.

When the warning magnet is passed by a train hauled by a locomotive, the control of the braking must only begin after a certain distance after the warning magnet, a distance which differs according to whether it is question of passenger or freight trains.

c) A gradient magnet, the indication given by which is independent of the position of the signal, comes after the warning magnet at a distance equal to 1/7 of the braking distance, according to the gradient of the section in question, of the worst braked train.

This distance which measures the gradient of the line is recorded on the locomotive and determines :

— The deceleration of the braking curve imposed;

— The distance in relation of the warning magnet at which the control of the braking of a train hauled by a locomotive begins.

d) The equipment on the locomotive should be designed in such a way that it can simultaneously follow two successive braking curves, only that one which was first recorded controls the running of the train; cancellation should always take place on the first curve and automatically divert the control of the running of the train to the second curve recorded.

e) In making a distinction between permanent and temporary speed restrictions, the running of the trains must be controlled in each restricted speed section by a succession of magnets :

— Braking magnet, put at the point where the braking of the worst braked train has to begin; it must check whether the braking has taken place correctly;

— Gradient magnet, determining the deceleration of the controlled braking;

— Speed restriction magnet (permanent or temporary) which starts up the mechanism which measures the authorised speed and — according to the type of magnet — determines the way in which this check of the reduced speed shall be made;

— Speed magnet which cancels the speed restriction control of the braking and substitutes control of the speed;

— Magnet cancelling the speed restriction (permanent or temporary).

The braking magnet and the speed magnet for one and the same restricted speed section cannot both be put within the braking zone of a stop signal.

28. Note.

To realise the ideal programme, set out in paragraphs 18 to 27, several types of magnets are therefore required.

It is possible that a thorough examination of all the cases which may occur on the railway system will show that some of these types are not needed. It must not however be forgotten that :

— The suppression of any given type of magnet reduces the possibilities of the device and makes it less capable of meeting all operating requirements;

— It is imprudent to suppress checks of the difficult cases without fear of the consequences, and merely retain the simpler cases.

The number of different types of magnets may possibly be reduced by using for certain indications a combination of two magnets of different types. The choice of such combinations is however limited by the fact that certain indications may have to be given simultaneously at one and the same place.

THIRD PART

DESIGN OF THE ARRANGEMENT WHICH SATISFIES THE IDEAL PROGRAMME

29. Object of the design.

The third part of the investigation has been devoted to the development of a system of control satisfying the conditions laid down in paragraphs 18 to 27.

These exceed the limits of this article and we have limited ourselves to sketching in some of the stages and some particular details.

The way in which the emission and reception of the indications of the various magnets would be achieved has not been considered in detail; the only thing fully studied has been their interpretation by the equipment on the motor unit.

30. Considerations on the subject of the slope of the braking curves.

If the deceleration on braking was constant all the braking curves would have the same slope and the only difference between them would be the scale of distances.

Actually if *a* represents this deceleration and taking the point of the stop as the origin of the times and distances run, we can write :

$$V = at \text{ and } L = \frac{at^2}{2}$$

whence $V^2 = 2a\ L$.

Making a^o = deceleration on the level;
i = gradient (up or down)

we get $V^2 = 2\ (a_o \pm i)\ L\ (1)$.

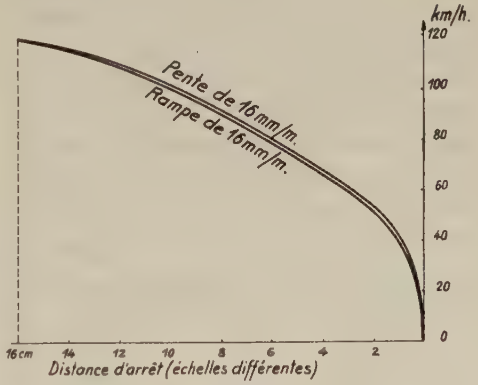


Fig. 13.

Translation of French wording :

Pente de 16 mm/m = Slope of 16 mm/m. — Rampe de 16 mm/m = Gradient of 16 mm/m. — Distance d'arrêt (échelles différentes) = Stopping distance (different scales).

The braking deceleration is not constant, however, but in practice, the above rule remains nonetheless more or less exact. Figure 13 represents the braking curve of a 2 vehicle motor coach with the ordinary brake on a rising or falling gradient of 16 mm/m with different distance scales so as to show by the same length their respective braking distances. We observe that the curves so obtained differ but little.

This important observation enables the control of the braking to be done by a single curve.

Equation (1) above shows that as long as the braking deceleration is constant, the square of the speed is proportional to the distance to be covered, starting from this speed to the stop.

Should practice confirm this rule, it would enable the control of the brake to be achieved in a relatively simple way. It is in fact easy to arrive at a figure proportional to the square of the speed and all that would be needed then would be to compare this figure with another varying linearly with the distance covered.

The graph of V^2 as a function of l (fig. 14) for the braking curve of a 2 vehicle motor coach on the level with the ordinary brake shows however that this hypothesis is not always confirmed in practice.

31. Application of a potentiometer to represent the braking curve.

a) Principle.

As a first approximation it is generally accepted that the voltage at the outlet side of a potentiometer is proportional to the ratio of the resistances r/R (fig. 15); this is exact in so far as the current I_2 given by the potentiometer remains low relatively to the current I_1 which it receives.

We write more exactly :

$$E = I_1 (R - r) + I_2 X$$
$$XI_2 = r (I_1 - I_2).$$

From which we get :

$$I_2 = \frac{rE}{r (R - r) + RX} \qquad (2)$$

To begin with let us try to find the general rate of the variation of I_2 in terms of r.

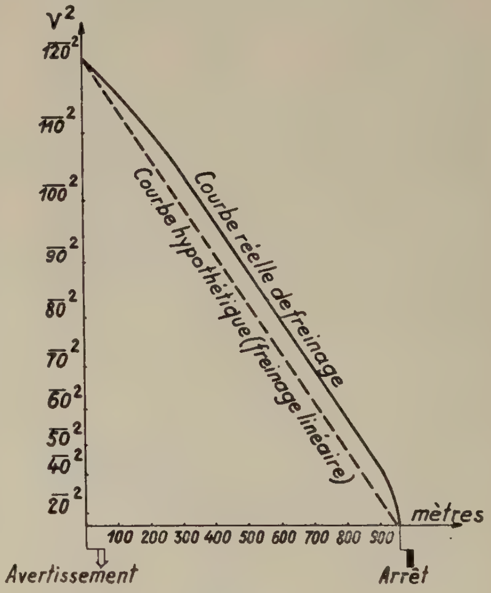


Fig. 14.

Translation of French wording :

Courbe réelle de freinage = Real braking curve. — Courbe hypothétique (freinage linéaire) = Hypothetical curve (linear braking). — Avertissement = Warning. — Arrêt = Stop.

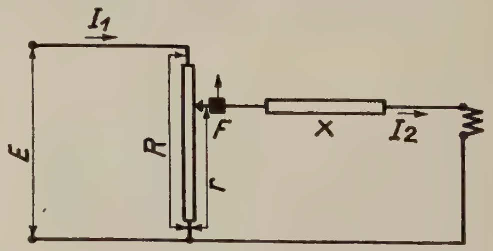


Fig. 15.

Let us draw (fig. 16) the vertical line (rE) representing the numerator of equality (2) and the parabola $[XR + r(R - r)]$ which represents its denominator. The mean value of the denominator (for r varying from 0 to R) being equal to $\left(XR + \frac{R^2}{6}\right)$ we can draw the vertical $\frac{rE}{XR + \frac{R^2}{6}}$ and then the general slope of the curve $I_2 = f(r)$ (in full lines in fig. 16); this latter cuts the vertical $\frac{rE}{XR + \frac{R^2}{6}}$ at the points A and B for which :

$$XR + r(R - r) = XR + \frac{R^2}{6}$$

therefore for $r = 0.8$ R and 0.2 R (approximately).

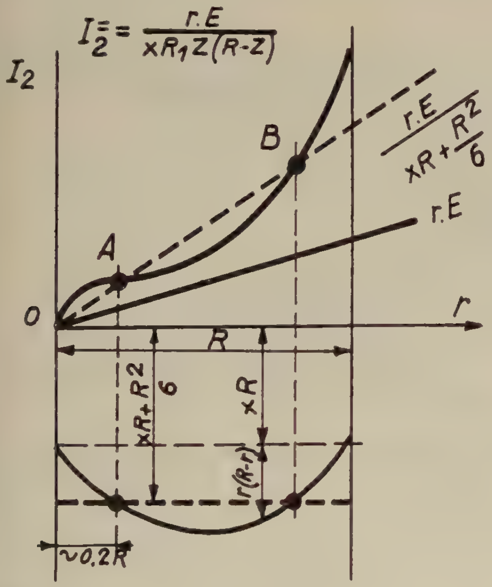


Fig. 16.

When considering the slope of the curve I_2, we find this curve could possibly be assimilated to a braking curve provided :

— The part OA (= 0.2 R) be suppressed;

— From I_2 a constant value (curve A′ B′C′ of fig. 17) be subtracted.

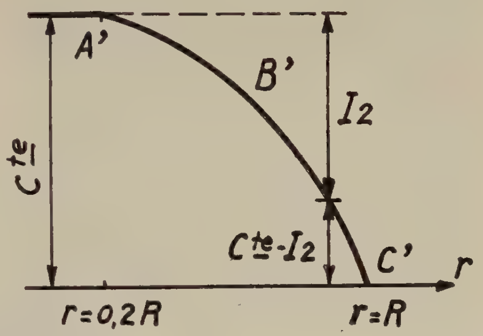


Fig. 17.

Figure 18 represents a scheme in principle which would make it possible

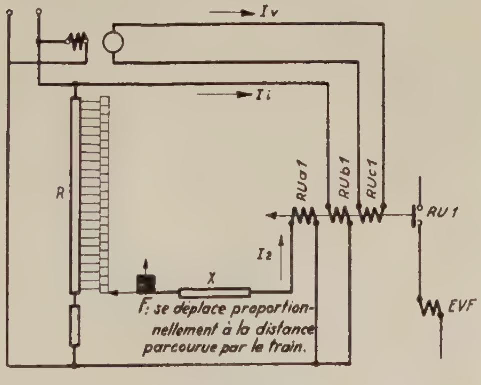

Iv
Ii
R
RUa1
RUb1
RUc1
RU1
I_2
X
EVF
Fi se déplace proportionnellement à la distance parcourue par le train.

Fig. 18.

Translation of French wording :

Fi se déplace proportionnellement à la distance parcourue par le train = *Fi* moves proportionally to the distance run by the train.

to reproduce by the windings RU*a* and RU*b* a value as a function of *r* such as that shown by the curve A′B′C′ of figure 17 (i.e. the speed authorised at each instant of the braking).

On the same figure 18 the winding RU*c* is fed by an axle driven dynamo : the current through it is therefore proportional to the speed of the train.

The windings RU*a*1, RU*b*1 and RU*c*1 are part of the same emergency relay RU1 the contact of which is inserted in the circuit of the inverse braking electrovalve (opening the train pipe of the automatic brake to the atmosphere when de-energised).

This braking electrovalve EVF will be de-energised for

$$I_v - (I_i - I_2) > 0$$

or

$$V_r - V_a > 0$$

inequality in which

V_r = real speed

V_a = authorised speed.

b) *Selection of the constants E, R and X to reproduce most faithfully the braking curve.*

Let us select haphasardly the following values for the constants E, R and X :

E = 100 volts,

R = 10 ohms,

X = 10 ohms.

and let us determine (see following table) for the increasing values of *r*, the value of I_2 (column 5) by means of the formula (2) above :

r	$R - r$	$\frac{XR}{r} = \frac{100}{r}$	$\frac{100}{r} + (R - r)$	$\frac{E}{(4)}$	(5) — 1.72	8.28 — (6)	$(7) \times \frac{120}{8.28}$
1	2	3	4	5	6	7	8
1	9	100	109	0.92	—	—	—
2	8	50	58	1.72	0	8.28	120
3	7	33.5	40.5	2.46	0.74	7.54	109
4	6	25	31	3.23	1.51	6.77	98
5	5	20	25	4.—	2.28	6.00	87
6	4	16.75	20.75	4.8	3.08	5.20	75.5
7	3	14.25	17.25	5.8	4.08	4.20	61
8	2	12.5	14.5	6.9	5.18	3.10	45
9	1	11.1	12.1	8.2	6.48	1.80	26
10	0	10	10	10	8.28	0	0

As the curve will be used starting from $r = 0.2$ R, we should subtract from the result obtaining in column 5, the value of I_2 for $r = 2$ ohms (i.e. 1.72 A). To obtain a curve assimilable to a braking curve we must then deduct the values of column 6 from a constant (which for the present case should equal 8.28 A so as to get a value nil for $r = R - 10\ \Omega$).

To be able to compare the values so obtained (column 7) with the instantaneous speeds of a braking curve, we must select the coefficient of the measuring apparatus so that 8.28 A corresponds to the speed of 120 km/h. Column 8 gives the figures of column 7 multiplied by the coefficient $\frac{120}{8.28}$.

From the scale of the abscissae if $1\ \Omega = 2$ cm will give a length of the curve of $8 \times 2 = 16$ cm identical with that of figure 13.

With the above mentioned method we obtain the curve of figure 19 (for $x = 10\ \Omega$).

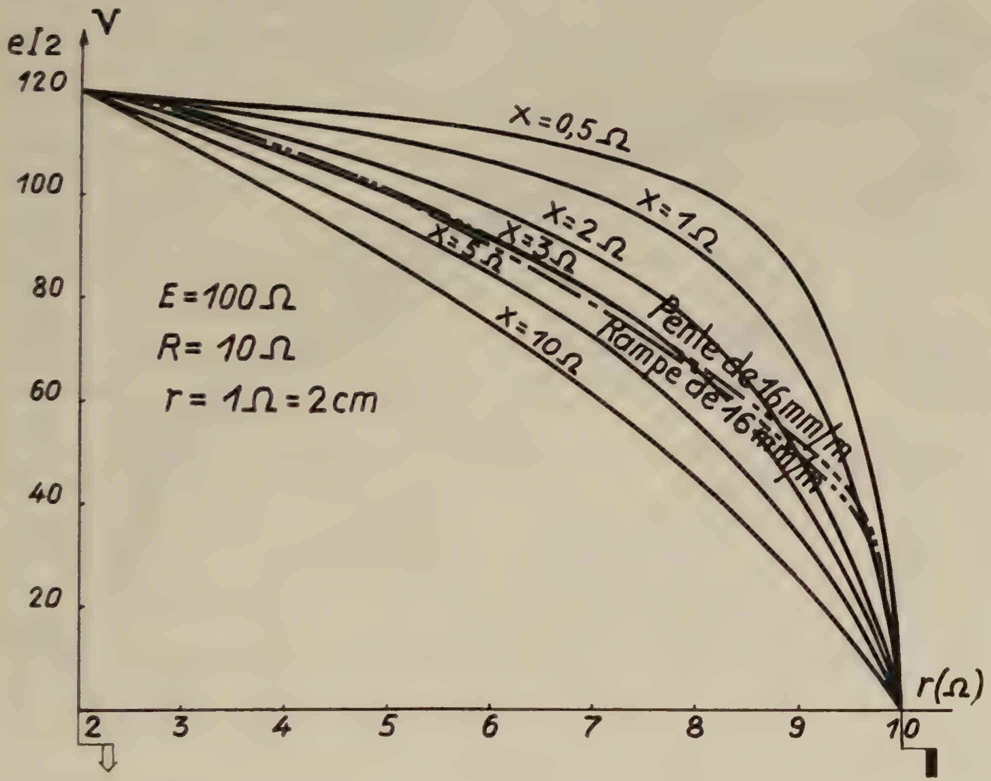


Fig. 19.

Translation of French wording :

Pente de 16 mm/m = Slope of 16 mm/m. — Rampe de 16 mm/m = Gradient of 16 mm/m.

By similar calculations for identical values of $E = 100$ V and $R = 10$ ohms and for the successive values of $X = 5$, 3, 2, 1 and 0.5 Ω, we get a whole range of curves (shown in fig. 19). It should be noted that for each different value of X, it is necessary to adjust the coefficient of the measuring apparatus to get the same scale of speeds.

If we retrace on the same figure 19 the two braking curves of figure 13, we observe that none of the curves measured coincides closely enough with the braking curves : we must therefore look for a method for modifying the measured curves, especially in their second part.

Finally, we retained two methods for reproducing more faithfully the braking curve.

1) Seeing that in conformity with the programme laid down in paragraphs 18 to 27, the extreme end of the braking control curve (for example starting from 20 or 30 km/h) need not be explored; the scale of r can be modified slightly so that the stop shall be controlled only some tens of metres after the stop signal. On figure 20 we have drawn a curve for

E = 100 volts,
R = 10 ohms,
X = 10 ohms.

scale of r : 8 ohms = 16.8 cm.

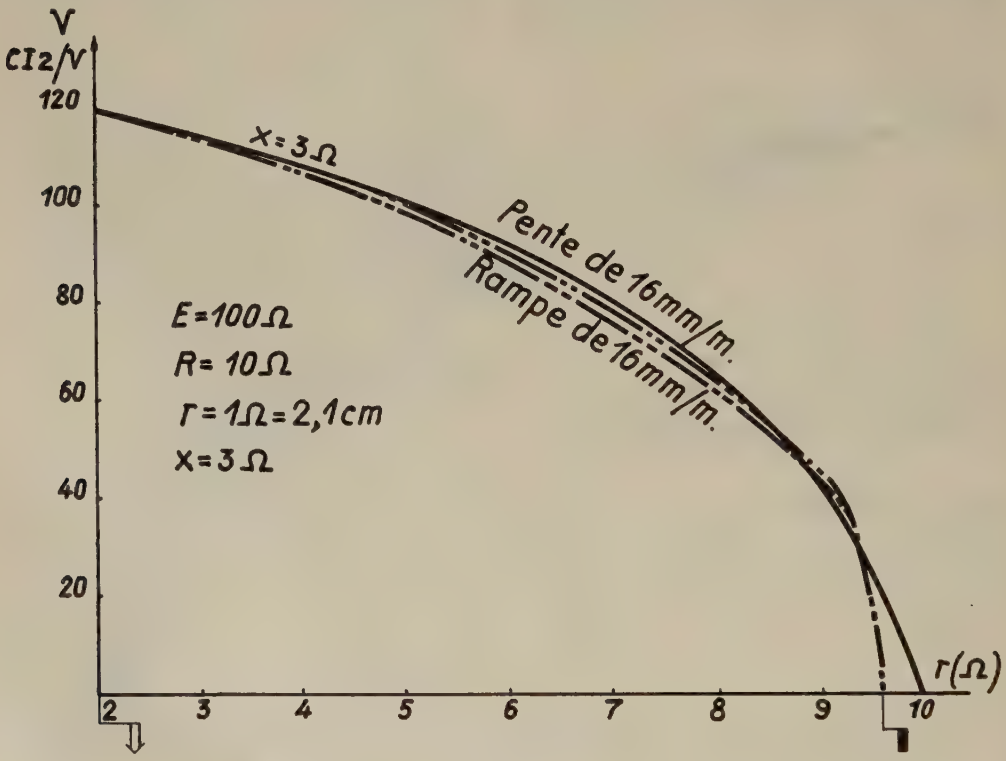


Fig. 20.

Translation of French wording :

Pente de 16 mm/m = Slope of 16 mm/m. — Rampe de 16 mm/m = Gradient of 16 mm/m.

The curve so obtained marries up with the two characteristic braking curves in a satisfactory manner.

2) A better result can be obtained by modifying slightly the scale of *r* towards the end of the control. This can be done by inserting between the two last studs of the rheostat, partial resistances slightly different from those of the other studs.

32. Influence of the inclination of the line.

From the above the inclination can be represented by a modification of the scale of the element (*r*) proportionally to the distance recorded between the braking magnet and the gradient magnet.

This can be done :

a) *Electrically :* by altering the ratio between the speed of rotation of the servo-motor moving the cursor F (fig. 18) and the speed of the train (measurement of the distance travelled).

Greater precision can however be obtained by using a servo-motor of the « Selsyn » type : now with such a motor the ratio between the speed and that of the train is constant.

b) *Mechanically :* by various methods too long to be discussed.

33. Other records.

Other arrangements enable us to obtain:

- The device which reproduces a braking curve affected by the inclination of the line (see par. 32);
- The recording of permanent speed restrictions;
- The recording of temporary speed restrictions;
- The adaptation of the system to the particular characteristics presented by the braking curves in passenger and freight services.

If we take into account only the particular items developed above, we can design a complete diagram.

34. Discussion and conclusion.

This study enabled the working principle of a layout which satisfied a control programme assuring complete safety (apart from passing a defective stop signal by written authorisation) to be developed whilst taking account of the operating conditions in the most open way.

The study was not extended so far as to establish the final details of the equipment, so that to complete it, it would be necessary :

- To determine exactly the characteristics of the different parts (coils, resistances, etc.) which affect the measures taken;
- To verify for the different operating conditions the conformity of the control curves recorded with one another;
- To give the mechanical details (carriers, cursors, etc.) the most adequate shapes and dimensions possible;
- To check the electric circuit layouts with the object of :
    - Possible simplifications which could be made to them;
    - Maximum safety, as a fault occurring in the equipment would cause the train to be stopped;

— Supplementary conditions to be laid down for ensuring safety when running on the wrong line;

— The methods of erection to be used in view of the motors in modern traction units (diesel and electric) being reversible.

The equipment made as a result of the investigation did meet a programme assuring complete safety but it included :

9 receiving relays with the necessary apparatus for dealing with *9 different indications;*

3 recording gears;

20 relays interpreting the signal;

24 auxiliary relays.

It can be criticised as including a too large number of parts subject to wear or likely to get out of order, requiring consequently maintenance. It may be that by applying *electronic* techniques a more rational equipment may be realised ultimately.

As a result of the wish to take into account all operating conditions, the equipment is very complicated but the object of the study was to verify just how far these conditions would lead us.

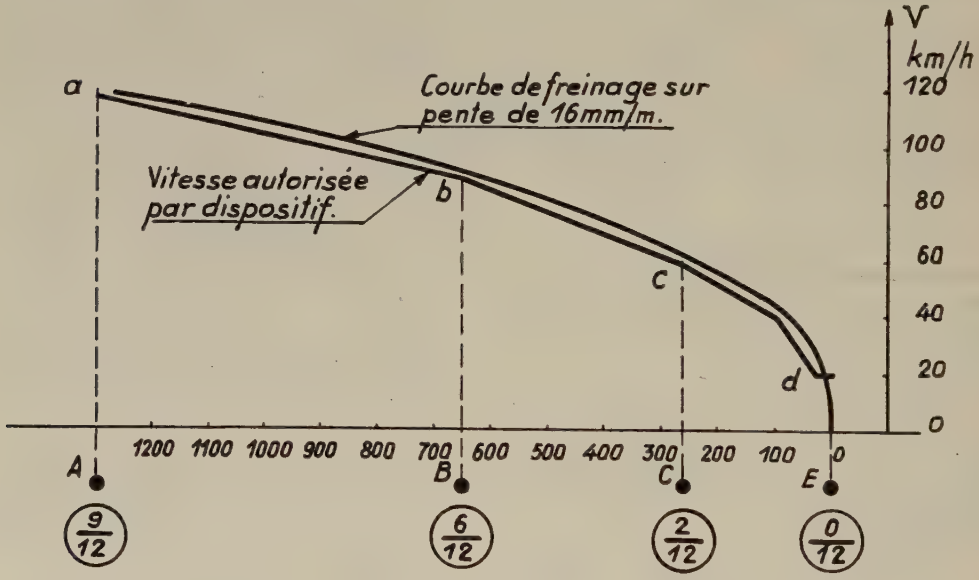


Fig. 21.

Translation of French wording :

Courbe de freinage sur pente de 16 mm/m = Braking curve on slope of 16 mm/m. — Vitesse autorisée par dispositif = Speed authorised by the device.

A continuous or almost continuous control of the braking in principle should take into account all operating conditions as otherwise it would result in unacceptable restrictions on the operating and driving of the trains. We have strong reasons for believing that the tests of continuous controls made previously failed in part because this condition had not been met.

Moreover, it would be a mistake to ignore a priori the control of the running of the trains in difficult conditions (combined signals, junctions, speed restrictions, etc...).

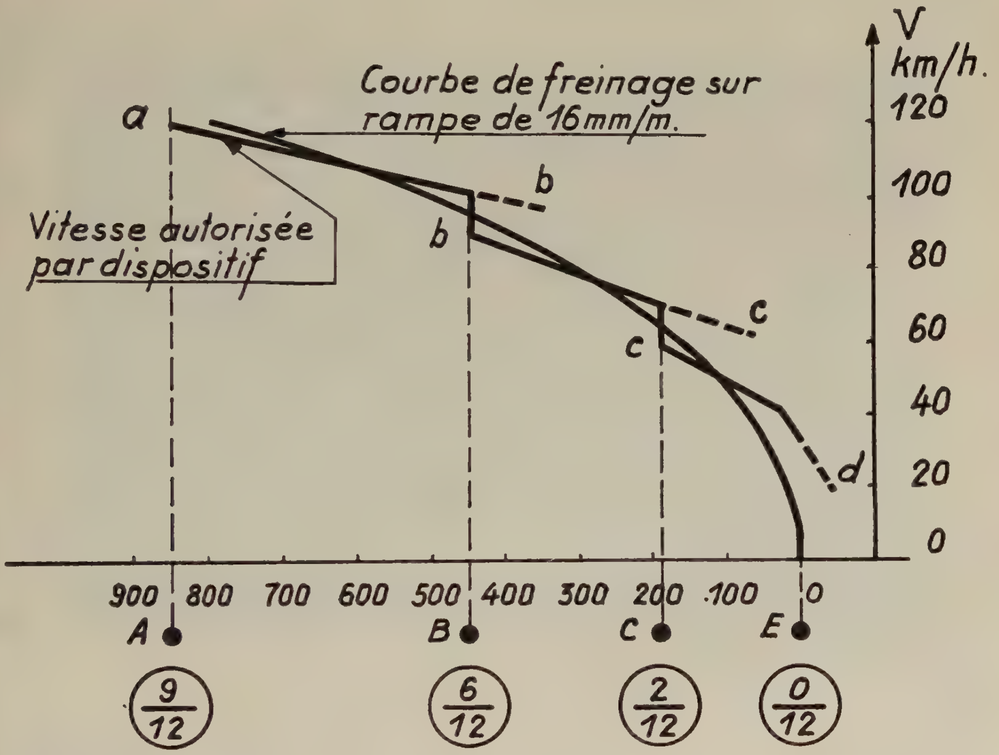


Fig. 22.

Translation of French wording :

Courbe de freinage sur rampe de 16 mm/m = Braking curve on up gradient of 16 mm/m. — Vitesse autorisée par dispositif = Speed authorised by the device.

Should the search for an electronic solution fail, it would be well to see if the continuous control of the braking would become possible (from the point of view of introducing it and from the point of view of the conditions imposed by the operating) by neglecting the particulars relating to :

- Varying deceleration according to the nature of the rolling stock;
- Inclination of the line;
- Wear of tyres;
- Use of combined signals;
- Existence of permanent or temporary sections under speed restrictions.

When doing this, the usefulness of applying the two artifices mentioned in paragraph 3 (checking the position of the units operating the brakes and automatic braking without being able to cancel it in certain exceptional circumstances) might be looked into.

Should the result of this further investigation also be negative, the conclusion has to be accepted that *continuous* control of the braking cannot be carried out practically.

Nonetheless, it would be interesting to check if in order to get greater safety, the control of the braking *by points* could not be completed :

— Either by applying the artifices raised in paragraph 3;

— Or by combining the control of the braking by points with a continuous control of the speed *between these points;* this latter control would this time be done without taking into account any of the operating conditions

Let us draw down (fig. 21) the emergency braking curve on a down gradient of 16 mm/m for a passenger train hauled by a locomotive, the whole being equipped with the ordinary brake (i.e., in fact, the train practically the worst braked), and let us suppose that track magnets are installed at the points A, B, C and E in such a way that :

— The magnet 9 imposes a speed reduction to a fixed curve *ab* (and then interdiction to exceed a speed of 90 km/h);

— The magnet 6 imposes a speed of 90 km/h at the point B and also a reduction in speed according to the curve *bc* (and then interdiction to exceed 60 km/h);

— The magnet 2 imposes a speed of 60 km/h at point C and also a reduction of speed according to the curve *cd* (and then interdiction to exceed 20 km/h);

— The magnet 0 causes an emergency application in the event of passing the signal at the stop position.

The indication 12 as denominator of the indications relative to the magnets 6, 2 and 0 means that these magnets permit the indication « resumption of running at 120 km/h » should the stop signal be restored to pass.

Figure 22 represents this same equipment in the case of running over a rising gradient of 16 mm/m. With such a layout the stop signal will never be passed by a distance of more than 75 m and the train driver will never be required to make abnormal brake applications.

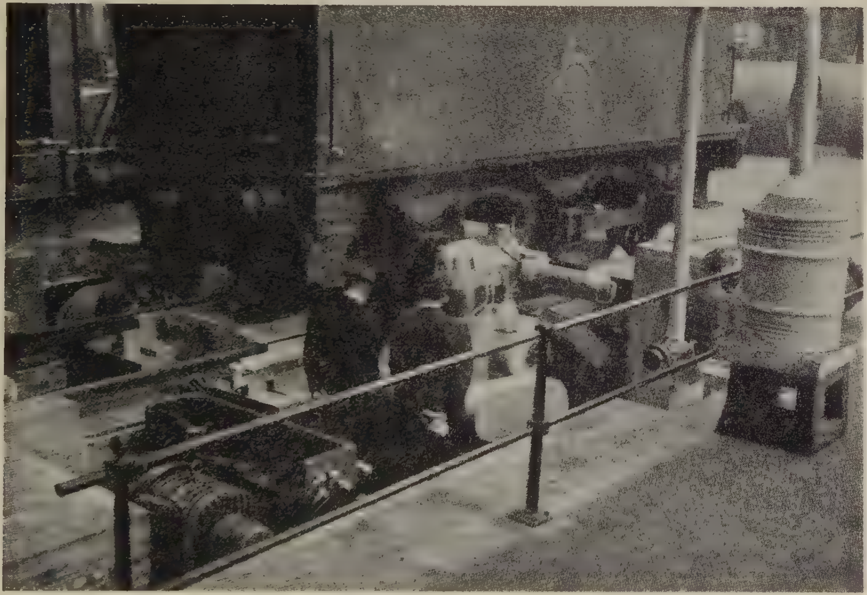
It is not difficult to imagine the application of this system to controlling speed reductions and to passing combined signals.

[621 . 4 (42)]

Rail-level tyre reconditioning machine.

Re-profiling without removal of wheelsets from locomotives or rolling stock.

(*The Railway Gazette*, October 10, 1958.)

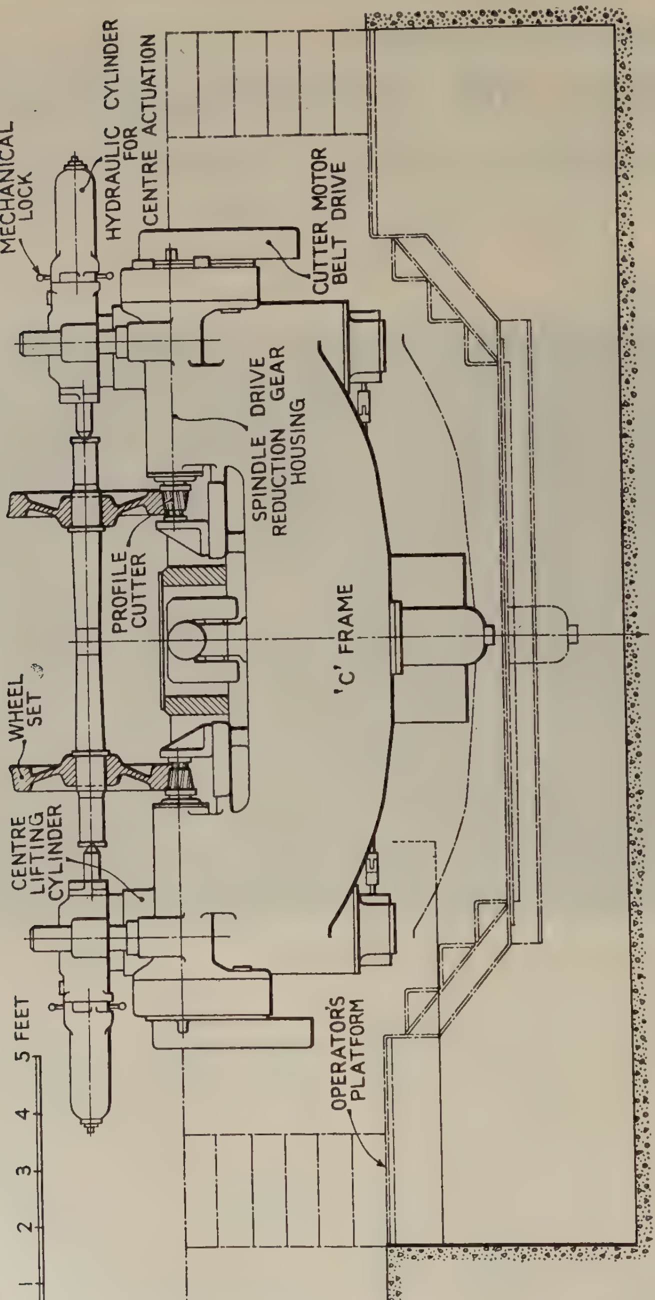


Wheel turning machine on test. Automatic swarf removal container on right.

Several Atlas standard wheel profile truing machines have been ordered by British Railways for maintenance depots; by the use of these tyres may be reconditioned quickly *in situ,* without the need for any dismantling work on the vehicle.

These machines are being built by the North British Locomotive Co. Ltd. for the Atlas Engineering Company, which latter holds an exclusive manufacturing licence from the patentees, the Standard Railway Equipment & Manufacturing Company, of Chicago, U.S.A. The machine illustrated is being installed in the new motive power depot at Crewe, and further machines have been ordered for the Southern, Eastern, and North Eastern Regions, of British Railways, and also for Ceylon and Iran. A recent delivery was made to the Commonwealth Government Railways of Australia.

The British-built machine is basically similar to the American model described in *The Railway Gazette* of June 3, 1955, modified to incorporate British Standard threads, and to cover metre, 3-ft. 6-in., 4 ft. 8 1/2-in., 5-ft. 3-in. and 5-ft. 6-in. gauges.



Section through pit, showing machine in operating position.

Wheel dia. between 28 in. and 54 in. can be accommodated and any required form of profile reconditioned.

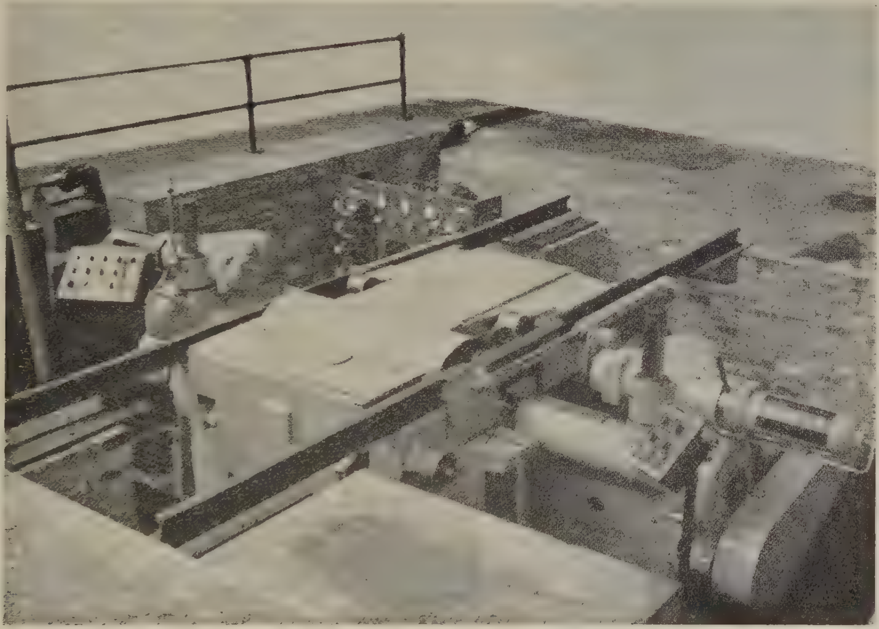
The machine operates as a milling machine. A feature of this is that even with tyre steel of up to 75 tons/sq. in. tensile, light cuts can be taken. This is an advantage, compared with conventional single point turning where it is frequently found that heavy cuts are necessary, and excessive material removed, in order to get under local hard spots.

Retraction as required.

The machine is installed below floor level in a pit at a through line in the depot, and the wheel flange and tread of any type of rolling stock is reconditioned without removal from the vehicle. When not in use the machine is retracted below ground, allowing the use of a through road over the pit.

Supported on pillars in the pit is a beam carrying retractable rails. These rails form a bridge for moving the vehicle into position on the machine. Also carried on the beam are a pair of stop rollers and a pair of drive rollers. When the wheelset which is to be reconditioned is cradled between the two sets of rollers, the drive rollers are lifted hydraulically and the rails retracted, leaving a gap below the tyre through which the cutters operate.

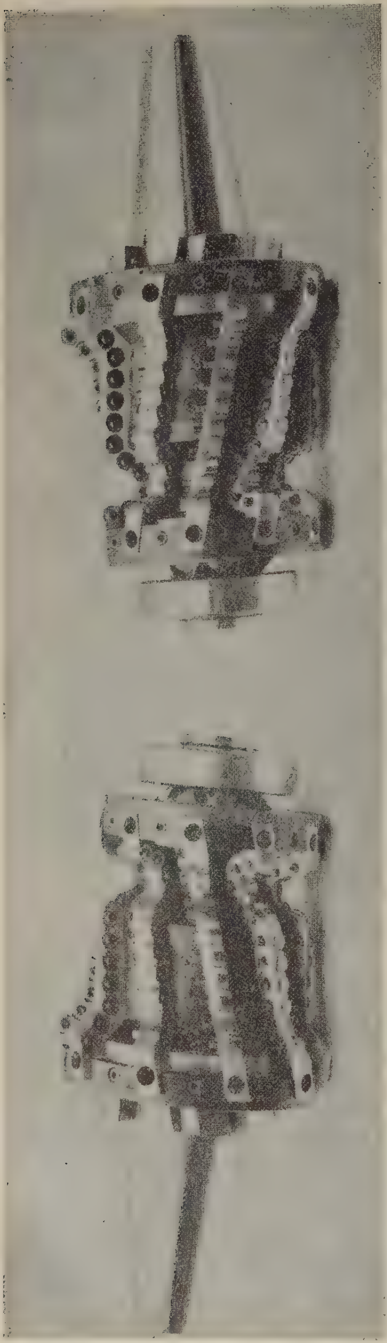
The 8 1/4-in. dia. drive rollers are driven by a 2-HP electric motor through reduction gearing; this friction drive to the flange of the tyre gives a feed rate past the revolving cutters of approximately 6 1/2 in, per min. Provision is also made for feed rates of 4 . 3, 8 . 6, and 13 in. per min. A certain minimum axleload is required to avoid



Machine retracted into pit, allowing through road : control panel on left.

chatter and in cases where the vehicle weight is below this, a hydraulically-powered holding-down attachment is used to give the additional pressure.

The cutter heads, drive gear, and auxiliary equipment is carried on a C-frame suspended from the main beam. This frame also carries two centres which are hydraulically engaged with the axle centres and then mechanically locked. The vertical movements of the complete C-frame and supporting pillars for the two centres are performed hydraulically by a fluid motor driving through a worm reduction gear. Elevation of the C-frame and centre supports is controlled by hydraulic clutches. The frame may also be moved horizontally to position the cutters. The centres ensure concentricity of machining, and by the use of vernier settings each wheel is machined to exactly the same dia. Each cutter is belt-driven at 106 r.p.m. by a 25-HP electric motor, driving through a reduction gear in the spindle assembly. Power for the hydraulic units is supplied by a pump driven by a 15-HP motor. An 80-gal. oil reservoir is incorporated. The hydraulic equipment is supplied by Stein Atkinson Vickers Hydraulics Limited and electric motors by English Electric Co. Ltd.



Pair of profile cutters, showing carbide inserts.

Profile milling cutters.

The profile cutters, which operate on the climbing miller principle, are of a special inserted tooth form designed for long life and good surface finish. They are made exclusively by Firth-Brown Tools Limited for Atlas Engineering Company. The steel body of the cutter, which is formed to the required tyre profile, is fitted with 10 equally spaced blades set at an angle in the body.

Each blade carries 11 cylindrical Atlas Mitia carbide cutting inserts. These inserts are reversible and may also be rotated in the blade. By using both ends and indexing the inserts 1/16th of a turn, 32 new cutting edges are available from one set of inserts. Cutter life is dependent upon the depth of cut and the tyre hardness. An average figure claimed for E-class steel is 130 pairs of wheels, with a proportionate increase on lower grade steels. The carbide inserts are suitable for steel up to approximately 600 Brinell hardness.

The maximum depth of cut is in the order of 0.35 in. at the flange, 0.170 in. at the flange throat, and 0.19 in. on the tread. It is normally found that one cut is sufficient to recondition each tyre. When cutters and centres are withdrawn as each wheelset is finished, the sliding rails are replaced and the vehicle winched along to bring the next axle into position.

No slurry is used and the swarf is collected in a chute and automatically conveyed by a blower fan to a container at the side of the pit. The machine is operated from a push-button control panel positioned to ensure a good view of the cutters. On the opposite side of the machine is an auxiliary panel for the centring control and emergency stop switches. The control equipment is supplied by Edward Holme & Co. (1931), Ltd., Altrincham.

The weight of the machine, 25 tons, is stated to contribute largely to the good tyre finish and absence of chatter. The set-up time, from moving the vehicle on the machine to setting the depth of cut, is approximately 8 min., and, it is claimed, a four-wheel vehicle can be completed in 1-1 1/2 h. No stripping of brake gear or other equipment is necessary. Since the introduction of this machine on American railway systems in 1953, 40 machines have been installed. They are used for roughly one-third of their total working time on motive power units and two-thirds on rolling stock.

656 .132

Knowledge of bus loadings.

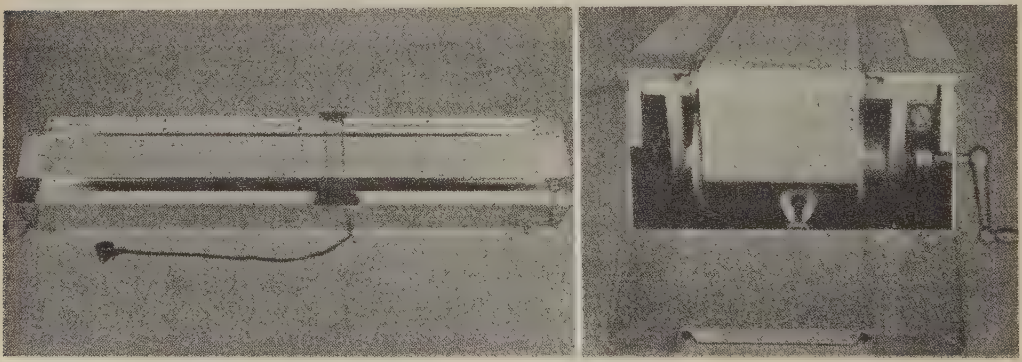
Use of West Yorkshire Loadmeter,

by H. N. Tuff, M.I.Mech.E., M.Inst.T.,

Director and General Manager, West Yorkshire Road Car Co., Limited.

(*Modern Transport*, October 18, 1958.)

There has always been a desire for fuller knowledge by bus operators of what is happening on the road in respect of loadings, and while cash taken has always been a guide and the knowledge of peaks an essential part of the information in the traffic department, nevertheless there were many gaps. In prewar days, when things were more leisurely, the management was able to obtain analyses of waybills to find out the stages on which the money was being taken. The need for information then was not so great; fare increases were not contemplated and costs were low. While economy has always been the desideratum of all efficient companies, the conditions then did not call for such a close examination of unprofitable routes or journeys as today.



Two views of the scanning apparatus for interpreting Loadmeter charts.

How to obtain statistics.

Today it has become necessary to have a fast issuing ticket machine, and the completion of waybills, other than the barest information, is often difficult during peak hours. If there is no audit roll on the ticket machine an analysis is extremely difficult and, indeed, where audit rolls are available the extraction of information can be tedious and costly. Certainly in this company all statistics from the waybills, etc., have been bedevilled by the incidence of return fares and contract tickets which are used on certain routes in great numbers. The sending of observers on the road to measure loadings can be costly, and we examined the various methods of obtaining these statistics by the cheapest process.

The first method was to get loadings photographically, and this proved effective only in the summer. The identification of points en route called for some knowledge, so that ultimately a clock was mounted in order that a picture could be taken every time the bell rang. The co-ordination of a picture on the top deck with one on the bottom deck proved again a long and tedious process.

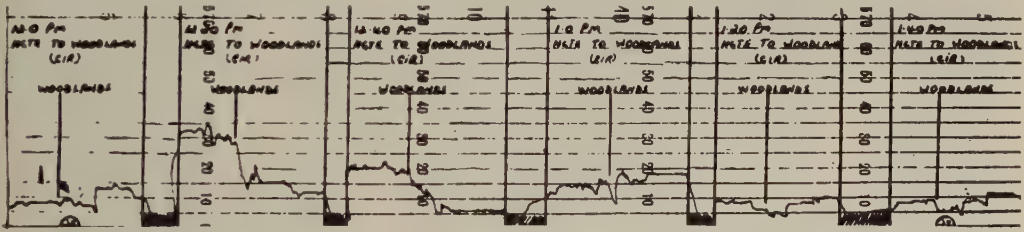
Recording ammeters.

The next step was to consider an electric contact on the seat which would, by some means, record on a drum the fact that the seat was occupied and, in order to reduce the cost of designing a machine, to find something already available. One's mind immediately turned to recording ammeters which are generally used on power plants, but we discovered that a recording ammeter was being manufactured which had been used in tanks for military purposes. This machine is robust, and in every way adaptable to installation in a vehicle. The cost was not unreasonable in respect of equipment and material. It was necessary to carry out a small modification to the recording ammeter to prevent the pen bounding off the paper roll under conditions of high vibration.

Arrangements were made to place a load of one milliamp for every seat occupied, and the micro switches are mounted under the seat, requiring a pressure of some 5 to 6 lb. to depress the switch. It is, of course, necessary to screw all seats down to avoid the inquisitive eyes of both staff and public alike; also to prevent our working on the base line, a constant load of 3 mA is applied, so that all the loadings we take from the graph are minus 3. We called the device the Loadmeter.

Ten fitted buses.

In this undertaking six double-deck vehicles have been converted to take the Loadmeter, and four single-deckers. Only six instruments are employed, and these can be fitted at will to either single- or double-deck vehicles. Generally speaking, on many of our provincial routes six buses will cover the whole service, but where this is not so we should take a second week's reading. Our object is to obtain a « bank » of information, so that on future occasions when we want knowledge of a route by suitable documentation we can have it.



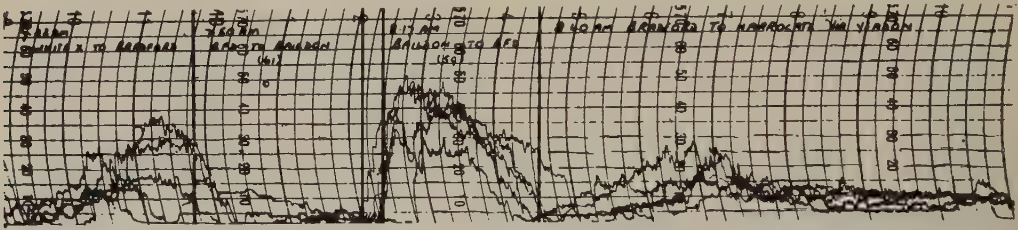
A simple diagram on the Woodlands-Harrogate circular route.

So far as reliability is concerned, our first vehicle and instrument has been in operation for over 10 months with no difficulty with the instrument at all, and this speaks well for the robustness of the design and the flexibility of the mounting. It will probably take two or three years of usage really to have a true picture of the routes and accurate documentation to enable the traffic officials to locate these records quite quickly.

Use of equipment.

A simple example of the use of the machine is to determine whether or not a double-decker is required as compared with a single-decker, or whether or not a 70-seater is necessary and for how long. This information is simply obtained by rolling a rotameter at the maximum loading position on the graph, and measuring the amount of time that a vehicle requires a greater seating capacity than that of the standard single-deck or 60-seat double-decker. These results are indeed surprising.

When these machines have been in operation for a long period I feel that new techniques will develop, and that its possession will place the traffic man in a strong position of knowing what really is happening without the tedious work which has had to be carried out in the past. A recent example of the economy in the use of this machine compared with the method of having a staff of observers on the road can be gauged by the following case. We required a complete week's survey of a number of vehicles on a route which would have cost us in labour approximately £ 230, and this is before the figures were collated. With the Loadmeter some 2 to 3 h in editing the rolls was all that was required, and I should add here the information was presented and accepted by the Yorkshire Traffic Court as evidence of loadings.



Five-day charts overlaid on one another on a series of busy morning journeys between White Cross and Bradford, Bradford and Baildon and back and Bradford-Harrogate via Yeadon.

Recording and interpretation.

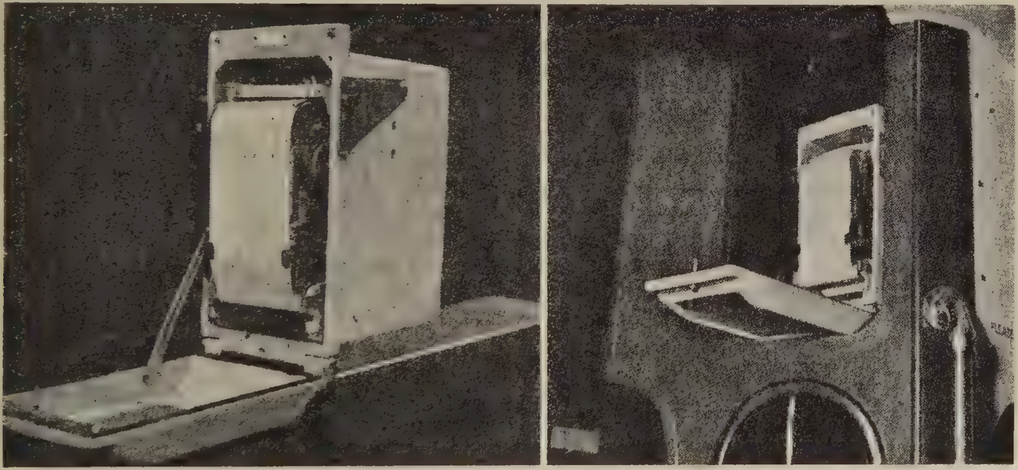
After our initial trials on special routes where we were seeking information, we have now arrived at a basis for recording. Generally speaking our Monday to Friday traffic is the traffic with which we are most concerned, and we record five days operating over each other, so that we have a pattern for every journey of the day. Originally our intention was to take the recordings in five colours; we no longer think this is necessary, but we can reinsert the roll into the machine at a later date, and trace with another colour a further set of a week's readings, superimposed on the five days which are already recorded.

Changes in trends.

This will show us changes in trends either of season or year. Where desired the average number of passengers can be recorded by using a plannimeter to measure each journey, and we have in fact done this. Where fares are on a basic rate per mile, it will be possible, provided contract tickets and reduced rate return tickets are not employed, to approximate the amount of money which should be taken for that journey. This has proved ineffective in this company because all our fares are on a tapered curve. We have contract tickets, children's tickets, dog's tickets, parcels and other items which would confuse the position, but the average number of passengers is quite useful. The figure of average passengers per journey is obtained by using a plannimeter, and where an undertaking has a punch card system this information can be included for later extraction to obtain broader pictures of traffic flow.

It is necessary to edit the roll, which we do on a frame illuminated from the back and calibrated on the front on a clear time scale, commensurate with the time scale on the graph. This is the only part of the arrangement which literally has to be done by hand, but once a graph has been taken a copy can be made and circulated to the officials who are concerned with the particular route.

The top scale on the scanner is a time scale, and the cursor is marked to the radius of the axis on the graph. The short piece of flex shown in the photograph indicates the lighting for illumination from the back.



The loadmeter apparatus and, right, mounted in a West Yorkshire single-deck bus.

A photograph is included showing the Loadmeter and one of the scanners, and in addition there are two graphs. The first one is a simple single-line graph of a single-deck route. The vertical line shows the seating capacity, and in the example it will be noted that the 12 o'clock run from Woodlands to Harrogate has extremely light traffic, but on the run from Harrogate to Woodlands it rise sharply. The thin line, as just before the commencement of the 12.20 and 1 p.m. runs indicates people taking their seats on the bus, but as the vehicle is operating the line becomes thicker, due to minor vibrations. The hatching at the bottom indicates standing time.

On a double-deck route.

The second illustration is a double-deck route Monday to Friday with the five days laid over each other. It will be noted that there is a 7.23 journey from White Cross to Bradford; a 7.50 from Bradford to Baildon; an 8.17 from Baildon to Bradford, and an 8.40 Bradford to Harrogate via Yeadon. It will also be noted that there are substantial variations from day to day, but nevertheless one is concerned with the pattern of the whole week. For example, White Cross to Bradford at that time in the morning is a reasonably busy run, but the traffic in the reverse direction is negligible as the vehicle is going against the general flow of traffic, particularly in the last few miles, when the vehicle picks up at Baildon and its environs, and becomes busy.

It will be noted that on one day the vehicle was late arriving at Bradford. At 8.40 the journey from Bradford to Harrogate via Yeadon indicates that a double-decker is really unnecessary on this journey, although it had been the custom in linking duties to include the vehicle. Naturally steps will be taken here to operate the run with a single-decker, thereby saving the difference in fuel costs in the operating of the two types of machine.

Ascertaining duplication needs.

The two graphs are but simple examples of the work of which the Loadmeter is capable, and when a « bank » is formed of all the information, then the general flow at different times of the day to and from towns can be extracted. The need for duplication and the extent in distance of duplication is another factor which we can deal with, and also the loading over common portions of road by vehicles operating on different services. It is hoped that this device will prove of general benefit to the industry, increasing the knowledge of traffic operations.

The application of the instrument could be extended and engineers wishing to make investigations into gearbox and clutch usage on routes may do so by coupling different current loadings to each of the speeds and one to the clutch for accurate measurement. The machine could also be used to measure average mean gradients by a suitably designed inclinometer where such information is desirable for true route comparisons.

The writer expresses to Mr. F. P. Arnold, chairman of West Yorkshire Road Car Co., Limited, his appreciation of the permission given to publish this article.

[385 .4 (54)]

How Public Relations can aid Administrations,

by B. S. D. Baliga,

Regional Superintendent, Eastern Railway India.

(*Indian Railways*, June 1958).

Public relations has been defined as « deliberate, planned and sustained effort to establish and maintain mutual understanding between an organisation and its public ». The Indian Railways, the largest public undertaking in the country, has great need of expert public relations effort — in relation to their million employees and in relation to the very much larger public they serve. The author refers here to some of the myriad problems confronting railway public relations organisations and makes a number of helpful suggestions how these could be tackled.

The growth in recent times of large business organisations has created the need for a new professional class the public relations staff. In U.S.A., the land of free competition, private enterprise and giant business organisations, advertising and public relations work has become such an important activity that it absorbs a sizeable proportion of the budget.

The profession has acquired a high status and commands good remuneration. A good number of present day business executives in U.S.A. started their working life as salesmen, in advertising agencies or on public relations establishments to work their way up. The quality of public relations work may decisively influence the growth and smooth working of a good and efficient business organisation.

In the final analysis, it is not only skill and efficiency by themselves but solid public relations work that brings success in life and this is true of individuals as well as of large business organisations. Good public relations work has thus become quite essential these days for the success of any large business organisation.

Public relations work calls for a dynamic and versatile approach towards the customers, which takes into account changing political and social conditions, needs of people, the limit to which satisfaction could be vouchsafed and the human element that cannot be ignored in the working of any large organisation.

The railways in India are the biggest single business organisation and the experience of the West in industrial management and public relations work is bound to be useful to us in improving our relations with all those with whom we have dealings — individual members of staff, organised labour, customers and other sister organisations.

Railways have been the constant target of criticism all over the world and in India, too, we have recently had more than what we on railways feel is justified as fair and informed criticism. We have to make attempts to improve our relations by scientific analysis of our deficiencies and work out a proper *modus operandi* in public relations work.

Educating Public Relations Men.

The Public Relations Officers on the railways, after independence, have been doing a heroic job within the severe limitations under which they work. These officers are not always trained or assisted well enough for specialised railway work, nor even kept well informed to be fully aware of facts. Factual data are seldom received by them from departments in reasonable time to permit a press release to be arranged while the subject remains topical. If the channels of information are atrophied, P.R.Os cannot obviously perform their functions well.

Railways abroad maintain close co-operation with the Press and most criticism of railways appearing in the letters to Editor columns in newspapers are answered by factual foot-notes in that very issue which carries the criticism through a good understanding with the Press.

Special efforts should, therefore, be made to educate our public relations staff in railway working as widely as possible and to put them in possession of full facts speedily to enable them to publicise the railway point of view in reply to Press criticism.

We shall now examine how railways can function more successfully in creating goodwill among their staff, their customers and the rulers. Public relations work of an organisation has two aspects — internal and external. The work includes handling of revenue yielding and publicity advertisements, of factual hand-outs to remove misconceptions, explanatory as well as educative, to change the customer's habits and selling new ideas.

Internal public relations.

Let us first deal with internal public relations. We have to deal with more than 1 000 000 of our staff. Ultimately, the success of railway operation and construction depends on their willing co-operation and improved efficiency. We could instil in them a sense of pride in their work, however humble it may be, and in their appearance while on duty. We could make known to them the important place they occupy in the railway scheme of things and explain the key position of railway transport in the national economy.

The railway workers should know the aim of the Plans and their long-term and short-term objectives and be helped to develop an *Esprit de corps.* We could make them feel that in case of injuries or accidents, their interests will be in safe hands and that devotion to duty involving extra hardship and risk to life would receive proper and generous recognition.

Films have been recognised as the most potent media of education and where we deal with staff not sufficiently literate, educational films should be widely made use of. Such programmes may be made more interesting by screening some information and entertainment films also.

We should not fail to publicise staff service conditions, avenues of promotion, recognition of merit and awards for new ideas and invention. Finally we should miss no opportunity to stress that economic improvement of the railway staff can be ultimately brought about only by improved performance and by giving proper satisfaction to the millions of the railways' customers.

Relations with organised labour.

Then comes relations with organised labour. Industrial labour has now gathered a lot of strength through organisation and is gradually becoming conscious of the same. Ideas of human dignity, equality and democracy have made a deep impression even on the minds of the most humble and illiterate worker due to the changes brought about in India during the last decade.

Relations with them could considerably be improved by *a*) acceptance of the fact that trade unionism has come to stay; *b*) admitting that they deserve better service conditions though the railways are unable to afford them right now; *c*) dealing with them on a human and as far as possible on a personal basis while turning down appeals, etc.; and *d*) efficient administration to give them their dues correctly and promptly. Unless senior railwaymen constantly exert to give lower paid staff their dues, they will not in the eyes of the masses be deserving the higher salaries paid to them.

It is now common knowledge that in the West they do not have such disparities in salaries as we have in India, and that our hierarchical organisation and higher salaries are only derived from the British colonial traditions. Supply and demand should not be considered by supervisors as the basis to decide the wage structure for even casual workers. A time may come when the supply and demand conditions even for the supervisors may force them to gang up and resist exploitation by financiers and bureaucrats.

Confidence in public.

Our most critical customers are the passengers who expect from the railways good service, punctual running of trains and reasonable amenities as a regular measure. While unruly behaviour by some of them upsets railway working and is to be condemned and widely publicised in a moderate and dignified way, it is to be admitted that most of the passengers do not approve of such things. They co-operate, even though passively, with the staff to conform to railway regulations.

Keeping their interest in mind, we should help to improve railway service, more fully explain unpunctual running and maintain, as well as possible, the existing amenities. During accidents and periods of abnormal working, we should be extra helpful to them and accept that we have inconvenienced them due to no fault of theirs. Such an attitude may make criticism less sharp and get us occasionally even a few words of appreciation.

Relations with trade and government.

Trading communities are mainly interested in the absence of route restrictions, free availability of wagons, quick movement, security of their property in handling and transit and generally good service. Since this class of persons is mostly educated and well informed, apart from making attempts to improve our efficiency, all we need to do is to give them timely advice of changes. We have to show the best use for available equipment and factually explain the reasons for shortages and inconveniences.

The incidence of running train thefts is unfortunately directly related to the law and order situation in the country. We can only hope for a steady improvement in this respect. We have also to consider speculative practices of « booking to self », selling « railway receipts » through banks which lead to demurrage and wharfage claims by railways, opening selling points on railway « plots », bogus registration, and dealing with goods known to be stolen.

It should be stressed that as long as such parties are not denounced and kept out of trade organisations, railway capacity to deal with complaints and serve traders better will remain severely limited. We should stress that as a public utility organisation, railways have to carry even uneconomical passenger traffic and provide expensive amenities at the cost of goods movement. If railways were treated as self-supporting commercial undertaking, goods could even now move faster and cheaper but only by reducing uneconomical passenger facilities.

We have also to deal with other important parties — State Governments, Posts and Telegraphs, Ports, and other statutory corporations. Some of these are Governmental or Semi-Governmental organisations. They are important customers and some of them have also the power to withhold assistance to the railways during emergencies. Relations with them call for a lot of tact as well as some firmness.

Need for social education campaign.

During the last few decades the railways have been trying to educate the public on things like the need and advantages of cleanliness, of the queue habit and of travelling light. Progress in these matters is bound to be slow, but some improvements are already being noticed. In regard to certain other habits deeply rooted in our traditions, only determined and sustained propaganda is likely to influence public opinion in favour of any change. If we could stop sale of *pan,* sugarcane, unshelled pea-nuts, tea in earthen pots, etc., in our stations, our platforms will have less litter and will be cleaner. After all, cleanliness is maintained not by employing an army of sweepers but by limiting littering as much as possible.

When even national polls are held quietly among illiterate voters with the help of election symbols, is the shouting in stations of wares during day and night for the presumed benefit of our illiterate brethren really necessary? Our platforms are heavily crowded with platform ticket holders, licensed porters, vendors, beggars and other non-descripts who have no bussiness with the railway. Should we not limit the number of persons on platforms and make a start with at least a few stations to introduce the American system of allowing only journey ticket holders on platforms, to reduce the crowding and the din? Could not our passengers be induced to eat less hot *puries* and that at meal time only on the occasional journey made by them, so that we could remove portable cooking stalls from over-crowded platforms altogether?

In the West where they are used to more comforts at home, they accept on their more frequent train journeys such discomforts as incidental to travel. They eat mainly snacks and manage with seating accommodation only. In our country we have to find train space for giving sleeping accommodation to some third class passengers when we are unable to give even seating accommodation for the rest.

What is more, our train schedules are slowed down due to the heavy shunting work involved in attaching and detaching carriages at junctions even in day time. Our trains did not have fast schedules even in the prewar days, but the successful demands made for stoppage of important trains at every influential man's home station have succeeded in slowing down schedules considerably and the railways consequently have to face bitter criticism from the long-distance travellers.

Lastly there is urgent need for improvement in the control of road traffic outside railway stations.

These are some of the ideas which may have to be « sold » to the concerned parties in mild doses.

Alternative means of transport essential.

There is considerable shortage of transport now in India and the important place the railways occupy in the second Five Year plan for development is a measure of this shortage. Even if our full Plan is put through, the passenger transport capacity will still remain very inadequate. It is essential, therefore, in our publicity to stress without respite this point as also the need for off-loading from the railways and for developing alternative means of transport, where parallel roads are available. If passengers are moved by road by putting more buses into service, over-crowding can be appreciably reduced in trains, passenger halts may be cut out in sections with parallel roads and it may be possible even to withdraw some short distance passenger services to release capacity for goods movement.

In Western countries, up to 50 % of freight between cities is moved by road, water-ways and pipe lines. Unfortunately here in India various local influences are brought to bear while drawing priorities and instead of developing road and water transport, even where there are good parallel roads and waterways available uneconomical branch lines are sought to be retained and even new lines proposed to be constructed. Such attempts, if successful, will only lead to diversion of resources and shortage of trunk movement capacity for moving essential industrial raw materials to factories, and to ports for exports bringing in valuable foreign exchange. Our line of publicity in this case should be « do with less railway transport and where possible off-load to roads and waterways in co-operation with road and waterway authorities.

Explaining railways' problems.

During accidents and progress of construction work in mid-sections and station yards, our users meet with inconveniences and delays and naturally grumble about their troubles. On such occasions every railwayman should become his Railway's P.R.O. to fully explain the position. In railway training schools the public relations aspect should be brought home to all the trainees to equip them to meet such emergencies.

Derby station in U.K. was being remodelled in 1954 and this was naturally causing much inconvenience to the public. British Railways met the situation by exhibiting a number of notices in the premises apologizing for the inconvenience caused and showing at the main entrance a framed picture of an artists' impression of the station as it would appear after remodelling. This had a good psychological effect on the passengers.

Similarly, at Euston station delays to arriving trains due to unforeseen works were being explained by notices with expressions of regret. In all such cases, we should not be content with just a small notification in the hidden classified columns of a daily newspaper.

Customer is always right.

We should accept mistakes readily, explain our difficulties and take criticism in good grace. While discussing safety on railways, we could by way of contrast point out the position on roads where most running vehicles are defective and there are no effective rules for medical examination, vehicle testing or to prevent overloading.

We should always meet criticism even at the personal level with a sense of humour, point out the human element in our large organisation composed mostly of semi-literate class IV staff and emphasise that the railways' interests largely coincide with those of customers and staff.

Accept that we are not as efficient as we would like to be and emphasise that we are constantly trying to improve.

Finally, try to avoid winning an argument with a customer, even if all his facts are wrong and all his logic faulty. In public relations work, one should never try to be entirely in the right. If the customer is not always right let him at least not feel crest-fallen.

[625 .172 (73)]

In new track-raising system . . . Spot board is spotted by radio.

(*Railway Track and Structures* October, 1958.)

Remote control makes it possible for foreman, sighting through telescope, to move motor-driven spot board back and forth as necessary to locate it on a high spot.

The assistant foreman, in a seated position, was gazing through a scope mounted on a carriage. He was looking ahead, over a jack block, also carriage mounted. to a spot board that was likewise mounted on wheels.

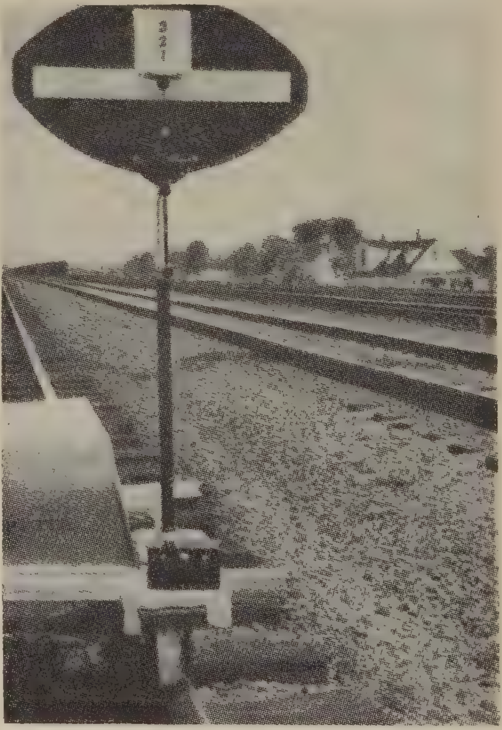
By manipulating push buttons on a box in front of him he could make the spot board move back and forth under its own power. By thus moving the spot board while sighting he could place it on a high spot without guesswork, and without assigning a man for this work.

The assistant foreman was engaged in a demonstration of a newly developed set of equipment for use in track-raising work. It is known as the Hayco Radio-Controlled Track-Finishing System. The Brice Hayes Company, Chicago, is the manufacturer.

Consist of the gang.

In addition to the assistant foreman the surfacing gang in which he was working consisted of a foreman, two machine operators and nine laborers. They were using a Jackson Multiple Tamper, a Railway Trackwork hydraulic liner, and the Hayco Radio-Controlled Track-Finishing System. The gang was making an average raise of 1 in. on a « dead » track, using five track jacks on each rail. The tie renewals already had been made on this track.

The three units comprising the new system consist of a sighting buggy, a « jack rabbit » buggy and a spot board buggy. These are operated in accordance with the same three-point raising method that is used commonly by track men all over the continent. The sighting buggy replaces the conventional sighting block, the



Spot board buggy moves under radio direction at speed of 5 mph. Target is pendant type.

« jack rabbit » replaces the conventional jack block and the spot board buggy is used in lieu of the common spot board.

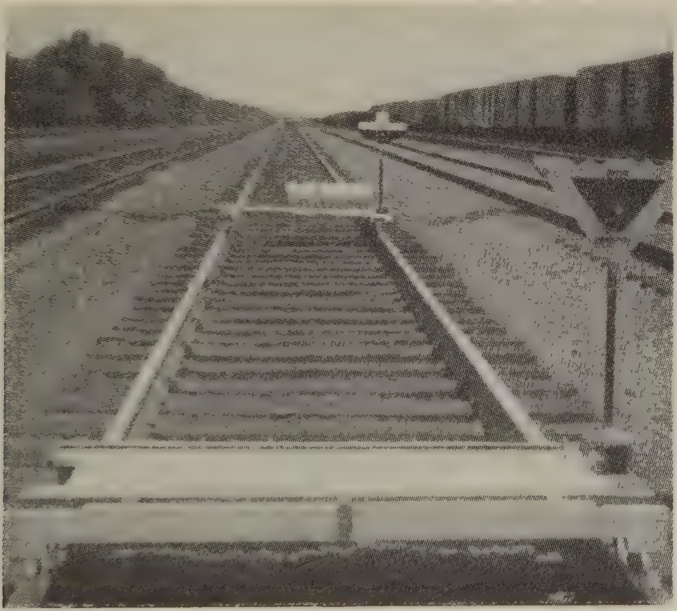
How it is used.

Here's how a foreman uses the equipment in making a 1-in. raise :

Seating himself on the sighting buggy, he adjusts the height of the telescope to the most convenient work height. If this happens to be 41 in., he sets the sight board of the « jack rabbit » to read 41 in. on its vertical tape. He then adjusts the spot board so that its tape reads 42 in. He is now ready to raise track.

Looking through the telescope, he sights toward the spot board. He then signals the jack men to raise the track until the upper edge of the sight bar on the « jack rabbit » coincides with the upper edge of the white line on the spot board. The track is then at the desired grade. After the rails are brought to proper cross level, the men move forward to the next raising point.

When it comes time to move the spot board forward, the sighting buggy and the « jack rabbit » buggy are held at their last working point. The sighting foreman then presses a button on the control box to blast a warning signal on the horn of the spot board buggy. Next he presses the button marked « forward » and holds it down. After a one second lag, while the radio tubes are heating up, the spot board buggy moves away.

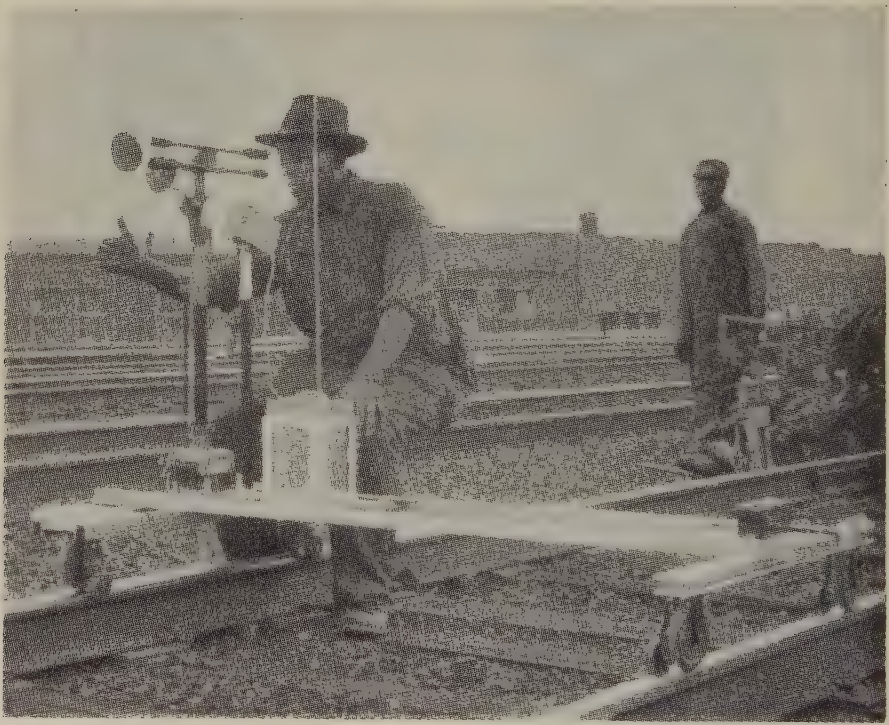


Sight bar on « jack rabbit » buggy (foreground) has notches in top edge to facilitate sighting on spot board (background).

Locating the spot board.

By watching the spot board through the telescope, he can note the high and low spots in the track. He can move the spot board from one high spot to another until he is satisfied he has the one he wishes to work toward. The spot board then remains at that point, and only a trickle of power for the radio receiver is being consumed from the batteries until the spot board is moved again.

The test run of this new equipment evoked favorable comments from the track supervisor, the foreman and the assistant foreman. The latter stated that he not only could see both the spot board and the jack block better, but there was also no question about his eye being at the right point at the sighting end. The track supervisor said that the system resulted in a truer surface than by eye raising. Also with a large surfacing gang the supervisor was of the opinion that one-half of a man's time would be saved each day just for relocating the spot board.



Sighting buggy carries telescope, push-button control box and radio transmitter. Later models will have flanged wheels.

Description of sighting, « jack rabbit » and spot-board buggies.

The track-finishing system described in this article is built around the Hayco Model HL Track-Lining Scope. It adapts the latter device to track-raising operations.

The buggies or carriages of the three units are essentially of the same size and construction. They have frames of steel and aluminum members mounted on four

6-in. diameter wheels, each having a 3-in. tread and ample flange. Hyatt-type bearings are used on all the carriages. The frames of the sighting buggy and the « jack rabbit » buggy are so designed as to keep all parts of the units from projecting outward beyond the 3-in. wheel treads, and to provide a clearance of at least 12 in. above the rails. This enables the units to pass and clear the low track jacks used with surfacing operations. Here are details of the three units.

The sighting buggy. — This device has two clamping blocks, one over each rail, to which the Scope is clamped. Provision is thus made for surfacing from the low rail on both right and left-hand curves. The right-hand clamping block is adjustable for placing the Scope directly over the gage side of the rail. Two more clamping blocks, placed about 6 in. from each Scope block, are for holding a vertical staff supporting a control box. The latter has three pushbuttons, one labeled « forward », another « return », and the other « horn ». These are for controlling the movement of the spot board buggy and for sounding its horn.

A radio transmitter is carried in a cage on the sighting carriage. The cage is provided so that the transmitter may be removed each night to avoid theft and tampering. The transmitter, complete with batteries and a collapsible antenna, operates on the Citizens Band, under Class C. A 5-W multi-channel system permits two channels to activate the propelling motor of the spot-board-buggy and another to control its horn.

Over one of the rear wheels of the sighting buggy is a plunger-and-spring type holding brake controlled by a lever.

Trailing behind over one rail is a seat riding on a caster-type wheel. Attached to the buggy by a steel strap, it carries the weight of the operator. It can be detached from one side and moved to the other rail.

The « jack rabbit » buggy. — This unit serves in place of the conventional jack block. When a powered tamping jack with a sighting block is being used by the surfacing gang, the « jack rabbit » unit is not required. It is equipped with a holding brake and an elevated push handle for moving it down the track. It carries a vertical shaft, clamped to a block over one rail, which supports a triangular sight board that presents an orange-painted horizontal sighting bar, 18 in. long. The top edge of the sighting bar has four half-moon segments cut out to permit the telescope operator to see the proper relation of the edge of the sighting bar to the distant white line on the spot board. When surfacing around a curve, two orange-painted side arms, normally folded slant-wise into an orange V, can be raised to form a sighting surface 42 in. long.

The sight board on this unit is of the self-leveling pendant type. It is equipped with a checking level near its top and an adjusting weight which may be run to the right or left as desired to keep the top surface precisely horizontal.

A feature of the « jack rabbit » buggy is the trailing level board. This rolls along the track with the buggy. It has a spirit level so that the men jacking up the track can always maintain proper cross-level. The level board may be lifted out of its sockets on the buggy for use on other portions of the track.

When this unit is to be used around left-hand curves, the entire buggy, weighing 75 lb., is picked up and reversed in position on the rails. The sight board is turned 180 deg. to face the telescope. The staff supporting the sight board is equipped with a measuring tape for determining the height of the top of the sight bar.

The spot-board buggy. — A spot board, a battery, a radio receiver and an antenna are carried on this unit. The 12-V D.C. battery is good for 60 Ah. A radio antenna and horn also are mounted on the deck of this unit.

The drive wheel of the spot-board carriage is an 8-in. diameter hard-rubber wheel which propels the unit at a speed of about 5 m.p.h. A spring exerts pressure to force the drive wheel down onto the running rail. Power from the 12-V D.C. motor is applied through a worm-drive reducer which functions as an automatic holding brake to maintain position when the carriage is stopped on a grade.

A vertical staff, clamped to a block over one rail, carries the spot board. The latter is elliptical in shape and has a 2-in. wide horizontal white line across a black background. The white line, 18 in. long, is self-leveling and is equipped with a checking level and a pendulum-motion dampner. Above and at the center of the white line is a 4-in. square white background marked horizontally in 1-in. increments. These are numbered 1, 2 and 3 and are to assist the sighting foreman when making changes in grade. The spot-board staff can be clamped to a block over the opposite rail when working around left-hand curves.

[**656** .25 (485)]

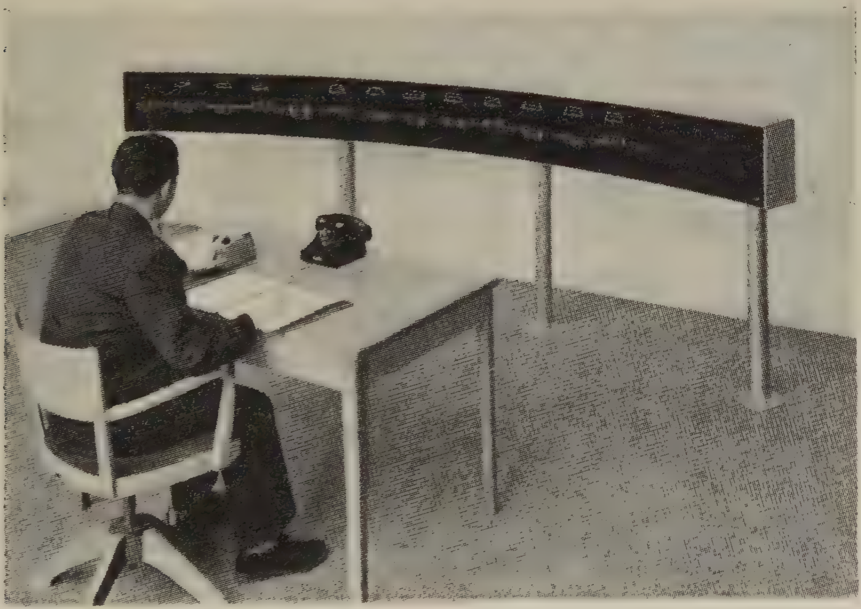
Keyset-operated C.T.C. system on the Swedish State Railways.

Rapid control and indication for relay interlocking installations.

(*The Railway Gazette*, September, 26, 1958.)

The first Centralised Traffic Control (C. T. C.) installation in Sweden was built in 1938 on the private Stockholm-Saltsjön Railway, 12 route-miles in length. It is operated in the conventional way, that is to say the buttons are situated on the track diagram.

The first C. T. C. installation on the Swedish State Railways was opened in 1955 between Ange and Bräcke on the main line to the North, a distance of 19 route-miles with four stations. This installation, and all others on the State Railways, built or projected, are constructed for « keyset » operation. The next installation was completed in June 1958 and is situated in the north on the Ore line between Kiruna and the Swedish Norwegian frontier, extending over 80 miles with 11 stations.

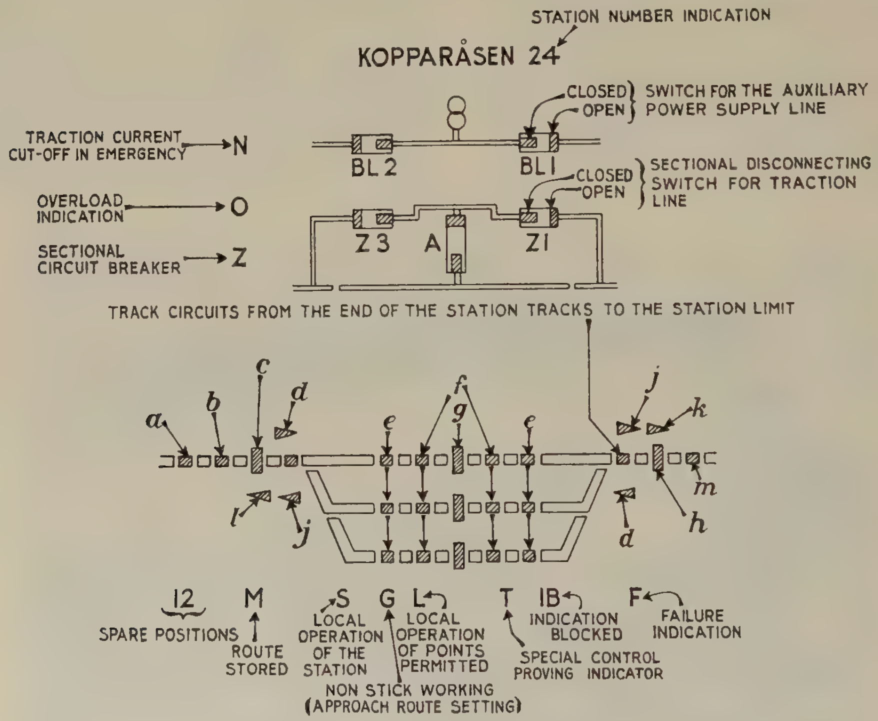


Keyset and track diagram at the C.T.M. office in Kiruna on the Ore Railway.

Other C. T. C. installations are in course of construction between Ljusdal and Ange, 65 miles, and Bräcke-Mellansel, 138 miles, both on the main line to the north.

All these installations have been or will be supplied by L. M. Ericssons Signalaktiebolag.

In June 1958 a further C. T. C. installation was opened in Sweden, on a part of the private Grängesberg-Oxelösund Railway. Conversion to C. T. C. of the remainder of the line, the entire length of which is 187 miles, is under way. This installation, however, supplied by Siemens & Halske, is not keyset-operated, the control switches being placed on the track diagram. All the lines are single-track.


STATION NUMBER INDICATION
KOPPARÅSEN 24
CLOSED
OPEN
SWITCH FOR THE AUXILIARY POWER SUPPLY LINE
TRACTION CURRENT CUT-OFF IN EMERGENCY
N
BL 2
BL I
CLOSED
OPEN
SECTIONAL DISCONNECTING SWITCH FOR TRACTION LINE
OVERLOAD INDICATION
O
Z 3
A
Z I
SECTIONAL CIRCUIT BREAKER
Z
TRACK CIRCUITS FROM THE END OF THE STATION TRACKS TO THE STATION LIMIT
a
b
c
d
e
f
g
e
j
k
l
j
m
d
h
12
SPARE POSITIONS
M
ROUTE STORED
S
LOCAL OPERATION OF THE STATION
G
NON STICK WORKING (APPROACH ROUTE SETTING)
L
LOCAL OPERATION OF POINTS PERMITTED
T
SPECIAL CONTROL PROVING INDICATOR
IB
INDICATION BLOCKED
F
FAILURE INDICATION

General arrangement of track diagram of Kopparasen Station.

a) Intermediate block section north;
b) First block section north
c) North line blocked;
d) Home signal;
e) Route indication;
f) Indication of track occupation;
g) Track temporarily blocked;
h) South line blocked;
j) Starting signal;
k) South traffic authorised;
i) North traffic authorised;
m) First block section south.

Study of types of C.T.C.

Before the installation of the Ange-Bräcke system, a committee of Nordiska Järnvägsmannasällskapet, the Danish-Finnish-Norwegian-Swedish Railway Association, made a study of the most convenient type of C. T. C. installation for the four Scandinavian countries.

Proposals submitted by the committee in 1954 contained the following recommendations. The stations should be equipped with modern relay interlockings, and the line between them with automatic signals. The safety of working should be fully covered by the interlocking and automatic signalling circuits, relieving the transmission system of any requirement other than that of ensuring complete reliability in the handling of the traffic. To reduce the time of occupancy of the line circuit by the transmission of a control or indication the system must be rapid acting. Furthermore, each control and indication should require as few impulses as possible. Rapid operation necessitated the use of telephone material, which also appeared to offer economic advantages. To ensure maximum reliability in operation, telephone relays should be used, but not selectors or electronic components. It was anticipated, however, that electronic components might be of value at a later date when they had attained full reliability. They would make very fast systems possible. (The Committee recommended 20-25 impulses a sec. as a desirable speed of transmission under present conditions.)

To simplify the work of the C. T. C. operator, the system should be as simple as possible and provide the operator with a good view of the entire track diagram from his desk from which he should also be able to actuate all controls. The ordinary controls and indications should therefore be few in number. The indications were proposed to be divided into two parts, the one comprising normal indications and the other such additional indications as might be required in exceptional circumstances. Finally the system should be easily adaptable to differing conditions.

On electrified railways, the usual case now in Norway and Sweden, cables are already available for both signalling and telephone purposes. Many of these cables are old, however, and have only a few wires available for C. T. C. purposes. The installation of additional cables would be expensive so a rapid acting system, which requires a smaller number of transmission lines, was therefore an important consideration. The C. T. C. installations built by the Swedish and Danish State Railways since 1954 have been largely based on these recommendations.

Ore Railway.

On the Ore Railway, between Kiruna and the Swedish-Norwegian border, every station has a modern relay interlocking with route-setting on the entrance-exit principle. On the Ange-Bräcke line the track between stations forms a single block section but on the Ore line is divided by intermediate signals.

Every relay interlocking has a track diagram, with facility for local operation under release from the operator at the Kiruna C. T. C. office.

To reduce the work of the operator, the relay interlockings are equipped to permit the receipt of orders for more than one route at a time; for instance, all orders required for the meeting of two trains at a station can be issued simultaneously.

At the Kiruna office the C. T. C. system consists of a track diagram, a keyset, a train graph, a control transmitter, an indication receiver, and registers. An additional keyset could be installed if demanded by the length of the section or the quantity of traffic. This may be necessary later on, when C. T. C. is extended to other parts of the Ore Line (Luleå-Narvik). Only one two-wire line is used for the transmission of controls and indications. If necessary, separate lines can be used for controls and indications, and more than one line can be used for indications if required by the traffic.

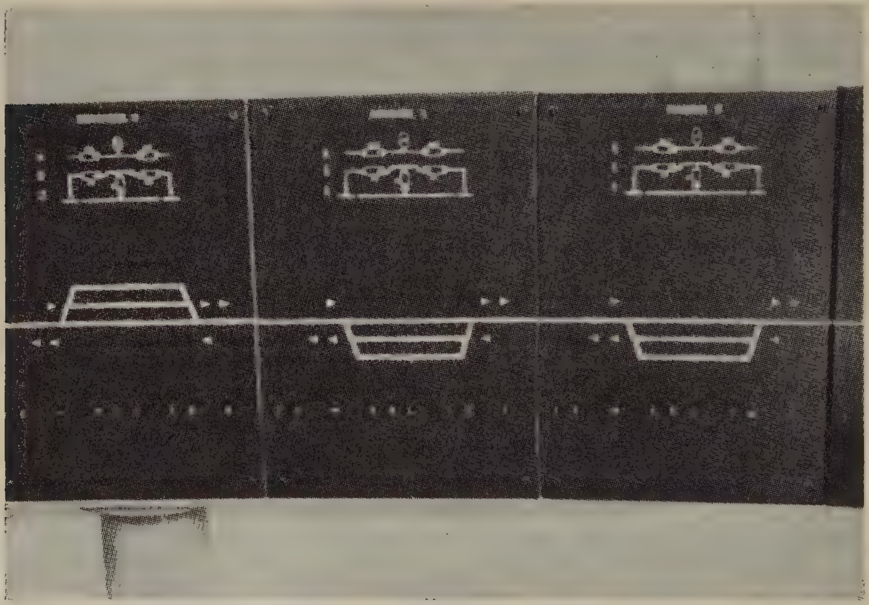
A five-pulse code is used for calling stations from the C. T. C. office. For control of a route, for instance, a six-unit code is added. The impulses are D.C. A control occupies the line circuit for about 0.6 sec. For transmission of indications from a station, the station number is first transmitted with the five-pulse code mentioned above.

One or more groups of indications are then transmitted, every group being represented by seven impulses. Each one of the seven impulses represents a function. The impulses are either positive or negative according to the condition of the indicated function. As mentioned above, the indications are divided into two parts, one of which is transmitted automatically, the other after special order by the operator. The first part is shown on the sections of the track diagram corresponding to the stations, the other on the lamp panel common to the entire track diagram. The time the indications occupy the line circuit varies according to the number of groups to be indicated.

The number of stations which can be operated by the system is 32, the number of controls per station 64, and of indications 98. For the present, two-thirds of these indications are sent automatically and one-third after special order.

As the most important lines are electrified, the C. T. C. system comprises also the control and indication of circuit breakers and disconnecting switches in the railway overhead line and auxiliary transmission line. The C. T. C. office has a train graph on which is shown both the graphic timetable for the line and the positions and directions of the trains.

It is also intended to conduct trials indicating the classes of trains, but it has been found unnecessary to indicate train numbers which would require much more complicated and very expensive equipment. The apparatus will be connected to the normal indicating system and operated by the keyset. The classes of train will be indicated by lamps on the diagram.



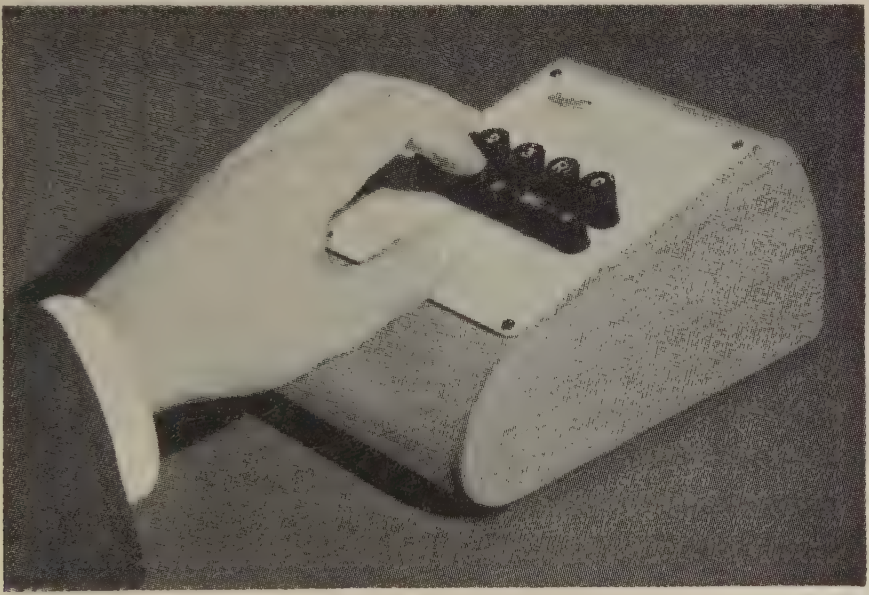
Part of the C.T.C. track diagram at Kiruna, showing station designations and code numbers.

Control equipment.

The accompanying illustration shows a section of the track diagram, namely Kopparasen Station with neighbouring block sections. Between each two stations on this part of the line there are up to three block sections.

The control equipment consists of relay sets for plug and jack connection. The control transmitter forms one relay-set, the indication receiver another, and so on. The track diagram in the C. T. C. office is made up of units, one for each station. These units, too, are connected via jacks, and are therefore easily interchangeable.

The operation of the system is as follows. The position of all trains is shown by the track circuit lamps on the track diagram, and a meeting between two trains at station 24 would be controlled as follows: assuming that a train coming from the left (north) is to enter the first siding and wait there until another train, coming from the right (south), has passed on the main track, the operator first keys number 2413; 24 being the station number and 13 the route number, that is for approach from north to first siding. As soon as digit 2 has been keyed the keyset is automatically connected to an unoccupied register. After keying of 24, the station number 24 lights on the part of the track diagram representing the station; and, after 13, the digits 1 and 3 light on the lamp panel. After checking that he has keyed the correct figures, the operator presses a start button. The control will then be transmitted as soon as the transmission line is free, and the lamps will go out.



Desk-mounted keyset for controlling the C.T.C. operation.

When the control covers a route, as in this example, lamps representing the route and signals start flashing simultaneously with the lighting of the aforementioned lamps. This arrangement still further simplifies the work of the operator. If the operator has keyed wrongly he can cancel the control by pressing a special button. When the control has been executed, this is indicated and shown on the track diagram by the lighting of the route lamps and signal lamps.

The operator can now, in one sequence, key 2412, approach from south for the meeting train 2422, exit northward for the meeting train; and 2423, exit southward for the first train. All these controls are stored in the relay interlocking, which is indicated in the C. T.C. office by the lighting of letter M on the station section of the track diagram.

When the first train has arrived at the station and stopped, controls 2412 and 2422 are executed. When the meeting train has arrived at the station, control 2432 is executed. These operations take place automatically. To provide a check that the first train has stopped, the staff on this train presses a button at the end of the entrance route. For short trains another button is situated at a suitable position.

To cancel a route already set up another control must be sent out, but this becomes effective only after a certain time interval has elapsed, determined by apparatus at the location concerned. Individual points can be operated by special controls, and other controls are possible for functions such as electrical heating of points.

Telecommunications.

For several reasons, it must at times be possible to operate the lines without C. T. C., and they are therefore equipped with the same telephone system as normal railways. The telephone system was in fact already installed before the C. T. C. system was envisaged.

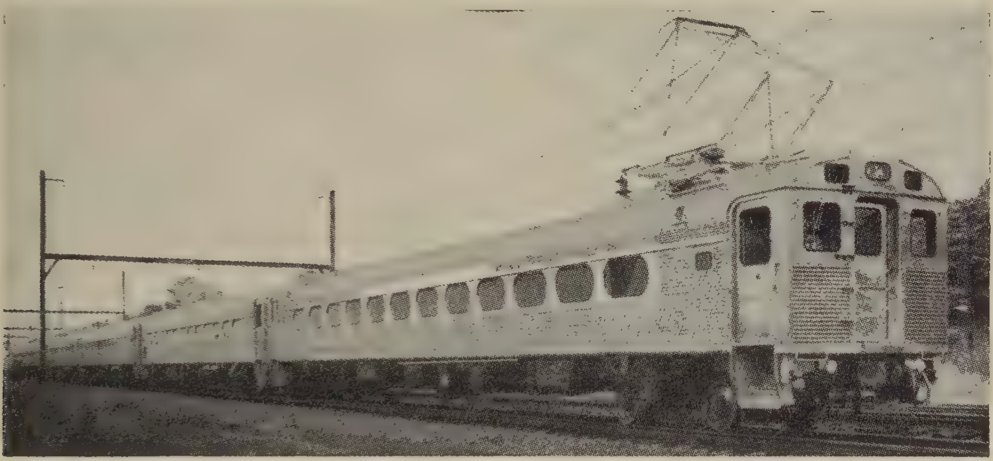
Since many of the stations are unattended, it has been necessary to arrange good telephone facilities to enable the maintenance staff to call the C. T. C office. For emergency purposes a special telephone system has been installed between the C. T. C. office and home, starting, and block signals. When the office is called from a telephone at a signal, the train staff announces to the operator the position, the number, and the direction of the train. The call is then cut off. The operator then calls back to the telephone at the signal. This procedure is adopted to eliminate mistakes as to the positions and directions of trains.

[**621** .338 (73)]

Light-weight coaches for electrified suburban services.

Multiple-unit design built by Budd for the Pennsylvania Railroad.

(*The Railway Gazette*, September 26, 1958.)



Six Budd-type stainless steel air-conditioned P.R.R. suburban electric coaches.

The Pennsylvania Railroad has introduced six Pioneer suburban coaches on its residential train services in the Philadelphia area. Based on the prototype Pioneer III coach, described in our issue of August 2, 1957, the new multiple-unit coaches are 85 ft. in length, compared with the 64 ft. of the standard stock in use on the line. Despite the extra length, they weigh only 40 t against the 58 t of the older equipment. The six air-conditioned stainless steel motor coaches were bought from the Budd Company at the price of $ 1 650 000, but it is estimated that in quantity production the coaches would cost rather less, probably some $ 200 000 each.

The Pennsylvania Railroad has an option on a further 44 coaches of this type, but has emphasised that the six it has must be run for some months to determine passenger reaction and test new design features. The original Pioneer III coach has now run some 120 000 miles in the U. S. A. and Canada.

The coaches have been designed and built by the Budd Company in co-operation with the engineers of the railway, and meet all strength and safety requirements of the Association of American Railroads, including a buffing load of around 350 t. They incorporate many features giving increased passenger comfort, have greater seating capacity than the coaches at present in use, are economical in operation and can be maintained at low cost. Air conditioning and automatic heat control equipment is fitted, and the interiors of the coaches are finished in colour-impregnated plastic. There are seats for 128 passengers in three of the coaches and 125 in the remaining three, which have toilet compartments. The seats are arranged three on one side of the gangway and two on the other. All six cars are motor coaches, each with four 100-HP 650-V. Westinghouse Electric D.C. traction motors mounted longitudinally in the bogies and driving through right-angle hypoid gear-drive units. Power is obtained, through Ignitron rectifiers, from the 11 000-V 25-cycle overhead supply system. Only one pantograph is provided on each coach.

Rapid acceleration.

The light weight of the coaches gives good acceleration characteristics, and 60 m.p.h. can be reached in 47 sec. The top speed is 90 m.p.h. Acceleration is automatic, being controlled by timing relays. On starting the motors are in series, but are switched to series-parallel connection as speed rises.

To enable them to run singly as well as in multiple-unit, all the cars are fitted with driving control compartments at both ends. The intention is that during peak hours they will operate as a single six-coach train but at other times they will be separated into smaller units and operated on different lines.

Two types of bogie are fitted to observe their performance under identical service conditions. Three of the coaches have Budd lightweight motor bogies of unconventional design and weighing less than 6 t each.

They are of alloy steel stampings welded together and carry the bodies of the vehicles on air suspension. The air springs are mounted on the bolster beams and engage pockets in the coach body next to the side walls.

The other three coaches have slightly heavier cast steel bogies by the General Steel Castings Corporation which are carried on combination air/coil springs. The Budd bogie has disc brakes mounted outside the wheels for easy servicing. These brakes now have finned double discs compared with the single disc of the original Pioneer III brakes. The General

	Pioneer suburban coaches		Standard P.R.R. multiple-unit coaches
	Budd bogie	*Cast bogie*	
Length over couplers	85 ft.	85 ft.	64 ft.
Passengers	128	125	72
Acceleration	1 - 3 m.p.h. per sec.	1 - 3 m.p.h. per sec.	1 m.p.h. per sec.
Weight in service order . . .	39 t. 18 c.	41 t. 12 c.	58 tons
Weight per passenger	697 lb.	748 lb.	1 806 lb.
Weight, bogies	10 t. 10 c.	12 t. 4 c.	21 t. 7 c.

Steel Castings bogies have Westinghouse brakes, and all cars are equipped with the Westinghouse air brake system; compressors are mounted on each coach and driven by 6-HP D.C. motors.

Each coach has a Safety Industries Inc. air conditioning plant which weighs some eight tons. This circulates cool air in summer and warm air in winter through ceiling ducts running the length of the coach. The system will maintain an inside temperature of 72° F even when the outside temperature rises to 100° F.

The seats are of foam plastic cushioning on frames fitted with stainless steel backs. The backs can be pushed over so that the passenger can face the direction of travel.

Principal dimensions of the coaches are given in the preceding table. Those of a standard multiple-unit coach are also appended for comparison.

[625 .171 (675)

Concrete cover protects Uganda line from rock falls.

(*Railway Engineering*, June 1958.)

Heavy rock falls along the Western Rift Escarpment of the Western Uganda railway line, some 190 miles from Kampala, have been the cause of minor derailments and considerable delays to trains, particularly during the rainy seasons, since the line was opened in November, 1956. These delays should be a thing of the past when the railway engineers complete a cover over the line in the most vulnerable section — the cutting through the sides of the Dura River gorge.

The railway crosses the Dura River about half way down the escarpment, overlooking Lake George, and to take the route across this river gorge at a suitable point it was necessary to make a deep cutting through the sides of the gorge. This area lies within the heavily-faulted region of the edges of the Western Rift Valley and is subject to frequent earth tremors. Considerable work had to be done during the construction of the line in sloping back the rock excavation to form reasonably stable slopes as the rock proved to be of a very shattered nature.

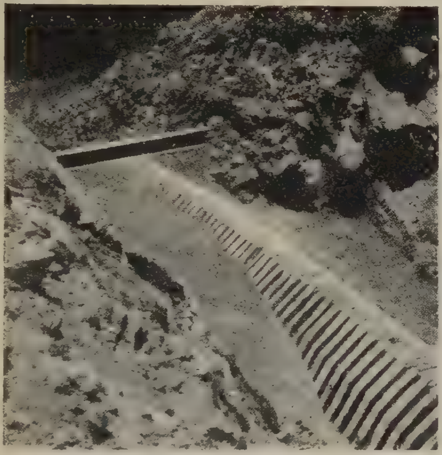
Since the line has been opened, however, several heavy rock falls have again been experienced, causing damage and delay to trains. The possibility of further cutting back of the slopes of the cutting was considered, but was thought likely to be difficult and dangerous if, at the same time, the line was to be kept open to traffic. An alternative solution was to provide a cover over the line which would prevent any

Line protection in Uganda.
A trainload of reinforced concrete arch ring units arrives at the site.

An arch ring is placed in position on the completed abutments.

further falls from coming down on to the track, and it was decided to proceed with this scheme.

Mass concrete abutment walls are first built, using precast concrete blocks as face shutterings; due to the limited working space available, the concrete for these walls is mixed in and placed from an engineering train taken into the section from the nearby Dura River station.


The arch rings in position.

The roof itself is formed of precast reinforced concrete arch rings which are manufactured at the precast concrete yard at Port Bell. Each unit weighs about five tons and is brought by rail to the site on railway wagons. Lift holes are cast in the units and these holes are so placed that they are at the centre of gravity of the units in the horizontal and vertical planes.

Once on site, the units are lifted by a gantry travelling on top of the completed abutments; the units are swung about the centre of gravity from the horizontal to the vertical position and then placed on top of the abutments. The joints between the units are filled with bitumen and covered with strips of bitumastic felt. The whole of the arch is then covered to a depth of some 5 ft. with earth so as to form a cushion against rock falls of the future.

The length of the completed cover will be about 400 ft. and the finished cost will be some $ 22,000.

[625 .143 .5 (42)]

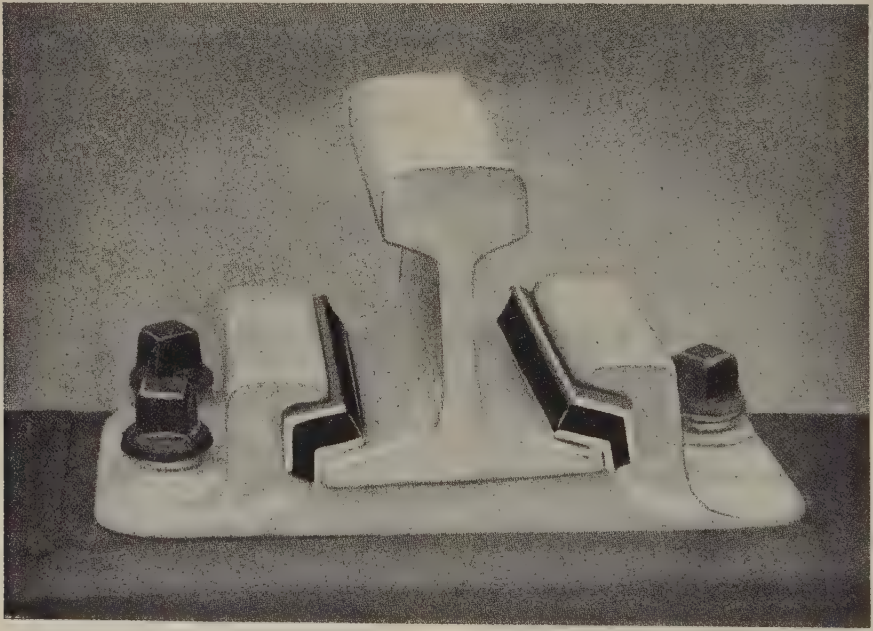
Rubber rail-to-sleeper fastening.

For use with flat-bottom rails, primarily on timber sleepers, and particularly with long-welded rails.

(By a correspondent.)

(*The Railway Gazette*, November 28, 1958.)

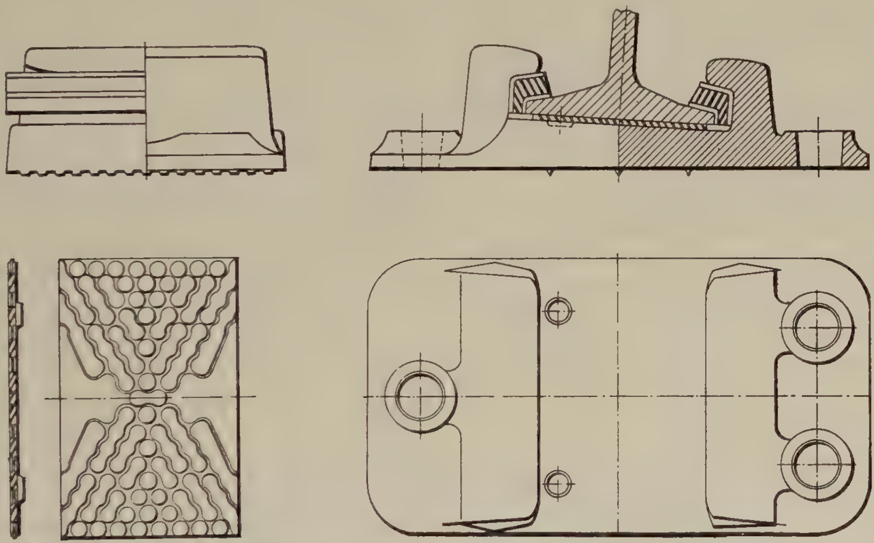
A *rail-to-sleeper* fastening at present on trial on British Railways is applicable to ordinary flat-bottom rails, but is specially designed to resist any tendency towards buckling in long-welded rails. Known as the Clyde Rubber Wedge Fastening, it has been designed initially for use with wooden sleepers but is being modified to suit other types. At present the Western Region is installing a ½-mile length, the Scottish Region a ¼-mile length, and in the Eastern Region a 60-ft. length has already been installed.



Cast-iron baseplate with jaws designed to fasten flat-bottom rails by metal-rubber wedges.

The advantages claimed are: (1) simplicity, no special tools or skilled labour being required; (2) cheapness in first, maintenance, and replacement costs; (3) over-riding safety afforded; (4) sufficient elasticity to protect the sleepers against impact and so increase their lives; and (5) no interference with track-circuiting.

In certain respects the fastening resembles the familiar chair-and-key fastening for bull-head rails but has several obvious advantages over the latter. In fact, it consists essentially of a cast-iron baseplate enclosing a rubber pad upon which the rail-base is held securely both vertically, transversely and laterally by metal-rubber wedges fitting tightly into jaws cast integrally as part of the baseplate.



Arrangement of rail fastening unit incorporating metal-rubber wedges and rubber pad.

Driving and extraction of wedges.

As the illustrations show, the wedges are slightly obtuse-angled in section and are parallel-sided. They bear on both the ends and tops of the toes of the rail, being driven and extracted with an ordinary keying-hammer and simple driving and extracting heads, very much as are bull-head rail keys. It will be noticed that the rail nowhere touches the baseplate, there being a resilient rubber pad and wedges between them. The baseplate can be secured to the sleeper as is a chair in any of the normal ways, with or without serrations of its base or other means of increasing grip. The driving of each wedge is calculated to exert both a downward and a horizontal thrust of 2 t on the foot of the rail. The rubber base pad has been specially designed after long experience, which also dictated the use of natural rubber. The pad has two projections fitting into recesses in the baseplate that keep it in position.

It is the resistance to torsion in the rail, insuring that the latter remains a stiff horizontal girder which makes this fitting so suitable to prevent buckling in long welded rails. Moreover, it is specially effective in resisting creep. Further advantages claimed are that the pre-chairing of the sleepers is possible, and the rail can be barred into the baseplate as is a bull-head rail into a chair. Also, lack of direct contact between rail and baseplate makes insulation more effective than usual.

Service of this wedge-fitting under heavy traffic and various climatic and atmospheric conditions on British Railways will be watched with interest.

NEW BOOKS AND PUBLICATIONS.

[**385** (08 (42)]

London Transport in 1957. — One volume (5 1/2 × 8 1/4 in.) of 84 pages with illustrations and numerous tables. — 1958, London Transport, 55 Broadway, London, S.W.1.

« London Transport » has published its report on the year 1957. Such a report, coming from one of the most important organisations in the field of public transport — London Transport carries nearly 11 000 000 passengers a day, owns 4 040 railway vehicles and 9 327 road vehicles and employs a staff of more than 87 000 — merits careful examination.

In a short introductory chapter, the report announces that for the first time since 1948, « London Transport » has ended the year without a deficit, taking into account the minimum contribution falling upon it in the costs of the « British Transport Commission ». This favourable result is, however, largely due to the petrol rationing which followed the Suez crisis at the beginning of 1957. The report also stresses that the subsequent reappearance of the traffic congestion in the streets of London proved that this is in fact the greatest handicap on the working of the « London Transport » road services. It finally stresses the interest of staggering working hours and makes a pressing appeal to the managers of businesses to collaborate with the public authorities on these lines.

A long chapter is then devoted to a detailed examination of the question of traffic congestion. The continuous increase in the number of private vehicles, not only deprives public transport undertakings of some of their clients, but also reduces the regularity of the services owing to the congestion they cause in the streets, and make the public still more disatisfied. In addition, the unbalance between the peak traffic and the traffic at slack periods is increased, which diminishes the profit from the stock. Finally, the consumption of fuel is increased to a far from negligible proportion. In addition to the measures introduced by the public authorities to improve traffic conditions, amongst which mention may be made of parking meters which appeared in the centre of London in 1958, « London Transport » has drawn up in its own field a plan for fighting traffic congestion. This plan includes not only putting into service high performance buses perfectly adapted to London traffic conditions, but also certain operating measures, such as the setting up of a centralised control, checking the running of the buses by means of electronic equipment (this latter, the « Bus Electronic Scanning Indicator » (B.E.S.I.) is the only installation of the kind in the whole world, designed by London Transport), and working in conjunction with the police when congestion occurs over alternative routes in order to avoid the repercussions on the suburban zones of delays in the congested central zone, as well as the provision of car parks at the Metropolitan stations. Finally, « London Transport » stresses once again the interest of the construction of the Victoria Line, the plans for which are now being made, but the financing of which still remains doubtful.

Chapter III comments on the operating results of the year : the number of passengers carried, as well as the number of passenger-miles declined compared with 1956. The causes are to be looked for in the increased tariffs, traffic congestion, the increase in the number of private vehicles and the extension of television.

Chapter IV examines the organisation of the road and railway services. The modifications made necessary by fuel rationing at the beginning of 1957 apart, the improvements made during the year are reported.

Chapter V justifies the increases in the tariffs which were introduced during 1957 and reports the policy followed in the case of cheap fares.

Chapter VI analyses the financial results of the year, and stresses the fact that in spite of the apparently favourable results of 1957, the financial stability of the undertaking is far from being assured, in view of the lack of equilibrium between the increased costs of wages and raw material on the one hand, and the tariffs on the other.

Chapter VII details the improvements made to the fixed installations and rolling stock. It describes in particular the reorganisation of the Chiswick workshops, which are responsible for maintaining and repairing the engines of the road vehicles, orders placed for buses intended to replace the trolleybuses, as well as the modernisation of the equipment in the garages. As regards the railway services, the report mentions the rectification of the layout of the routes at the Metropolitan station of South Kensington, the putting into service on the Piccadilly line of two new prototype rakes, the bogies of which are fitted with rubber springs, as well as various other works on the permanent way, signalling and electrification.

After a chapter devoted to the training and remuneration of the staff, the report ends with a study of the development of the population in the area served by the « London Transport ».

The report is completed by detailed statistics concerning the working of the undertaking and its material and financial position.

R. S.

[**625** .14]

ANTIA (K.F.), Former Chief Inspector attached to the Ministry of Railways, India, Central Standards Office. — **Railway track. Design, construction, maintenance and renewal of permanent way with notes on signalling, bridge maintenance and manufacture of track materials.** — One volume (5 1/2 × 9 in.) of 447 pages, copiously illustrated. — 1957, Bombay, published by the New Book Company Private Ltd., 188-190, Dr. D. Naoroji Road. — (Price : 16 Rs).

We have already reviewed a previous edition of this work in the Bulletin (*), bringing it to the notice of railway specialists as a practical guide to the permanent way, its construction, maintenance and renewal. It gives, in particular, the most recent maintenance methods used in India, and calls attention to the very important relationship between the movement of the wheels and the form of the rails. The stability of the rail, the sleepers and the track as a whole are the subject of a very interesting chapter in which theory, kept within reasonable limits, is used as a basis to support practical considerations. The description of the points, crossings and sleepers takes two whole chapters, and considerable importance has been attached to technology and the acceptance of the materials used. Finally, the author has been at pains to complete his work by certain information concerning signalling, interlocking and the maintenance of bridges, which those responsible for the maintenance of the permanent way must not overlook.

A. J.

(*) Bulletin for May 1951, p. 321.

[621 .3]

Lexicon der Hochfrequenz-, Nachrichten- und Elektrotecknik, Band 2. — *(Technical Dictionary for high frequency, telecommunications and electricity*, Vol. 2). One volume, (4 3/4 × 6 1/2 in.) of 808 pages, illustrated, bound. Published by Curt RINT. Editors : Verlag Technik, Berlin and Porta Verlag KG, Munich. (Price : 28.75 DM.)

Volume II of this Dictonary follows the same lines as the first volume (*). Published in German with a translation of the terms into English, French and Russian, it is indeed a real explanatory dictionary of terms used in industrial electricity or in the special techniques of acoustics and telecommunications.

The notions applied in the methods of calculation relative to these techniques, as well as the terms used in other fields — physics, elasticity, etc. — which are often referred to in electrotechnique are also explained.

Volume II deals with the words which begin in German with the letters E to J.

The book is completed by numerous tables and diagrams in the text, and covers such widely different subjects as electro-erosion and the Franklin aerial, filtering circuits and rectifiers, dynamos and impulse generators with their application to telegraphy and welding.

F. B.

(*) See « Bulletin » for the month of November 1958, p. 1658.

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ARRAMBIDE (J.), Civil Engineer of the National Bridges and Highways School, Chief Engineer of the Technical Department of the City of Paris, and DURIEZ (M.), General Inspector of Bridges and Highways. — **Aggregates, bonding agents and hydraulic concretes, usual reinforcement steel and metals.** — One volume (6 × 9 1/2 in.) of 600 pages with illustrations. — Paris (IX^{e}), Editions du *Moniteur des Travaux Publics*, 32, rue Le Peletier. (Price : 2 300 French francs; 2 475 French francs post free).

This lively work, thoroughly up to date and including all the necessary practical information, is intended for the use of Building and Public Works engineers and technicians as well as architects.

It deals in turn with :

— aggregates for hydraulic concretes, hydrocarbonised concretes and road cements;

— hydraulic cements (lime and cement) : regulations governing manufacture and use; accelerators and retarders of setting or hardening; strength, shrinkage, cracking, alteration; harmful waters; the protection of the work :

— mortars and hydraulic concretes : properties and factors which influence their characteristics; behaviour under particular conditions; concretes for making roads; work by the sea;

— the usual steel and metal reinforcements used in Building and Public Works : welding; corrosion.

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